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FROM

The Station

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UNIVERSITY OF VERMONT
AND STATE AGRICULTURAL COLLEGE.

TENTH
ANNUAL REPORT
—OF THE—
VERMONT AGRICULTURAL
EXPERIMENT STATION
1896--97.

MONTPELIER, VT.:
VERMONT WATCHMAN COMPANY,
1897.

UNIVERSITY OF VERMONT
AND STATE AGRICULTURAL COLLEGE.

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ANNUAL REPORT

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1896--97.



MONTPELIER, VT.:
VERMONT WATCHMAN COMPANY,
1897.

THE VERMONT

Agricultural Experiment Station.

BURLINGTON, VT.

PRES. M. H. BUCKHAM, *Ex-officio, Chairman.*
HON. E. J. ORMSBEE, Brandon.
HON. CROSBY MILLER, Pomfret.
HON. CASSIUS PECK, Burlington.
HON. G. S. FASSETT, Enosburgh.

OFFICERS OF THE STATION.

J. L. HILLS,	Director and Chemist.
G. H. PERKINS	Entomologist.
L. R. JONES,	Botanist.
F. A. WAUGH,	Horticulturist.
F. A. RICH,	Veterinarian.
*CASSIUS PECK,	Farm Superintendent.
B. O. WHITE,	Assistant Chemist.
C. H. JONES,	Assistant Chemist.
†D. D. HOWE	Farm Superintendent.
J. C. ROBINSON,	Dairyman.
MARY A. BENSON,	Stenographer.
E. H. POWELL,	Treasurer.

*From Feb. 1, 1897.
†To Feb. 1, 1897.

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The Station.

ANNOUNCEMENT.

The Vermont State Agricultural Experiment Station was established in accordance with an act of the General Assembly, approved November 24, 1886, for the purpose of promoting agriculture by scientific investigation and experiment. The station was established in connection with the University of Vermont and State Agricultural College, and for the past eight years has received the funds appropriated by Congress under the provisions of the Act commonly known as the "Hatch Act," approved March 2, 1887. The State appropriation expired in 1890.

The station is prepared to analyze and test fertilizers, cattle foods, seeds, milk, and other agricultural materials and products, to identify grasses, weeds blights, etc., and insects, and to give information on various subjects of agricultural science for the use and advantage of the citizens of Vermont.

All chemical analyses, etc., proper to an experiment station, that can be used for the public benefit, will be made without charge, so for as time and means permit. The Station will undertake no work the results of which are not at its disposal to use or publish if deemed advisable for the public good. The results of each analysis will be promptly communicated to the party sending the sample. Those that are of general interest will be published in the annual report or in bulletins for free distribution. The work of the year will be summed up in the annual report of the station.

It is the wish of the Board of Control to make the station as widely useful as its resources will admit. Every Vermont citizen who is concerned in agriculture, whether farmer, manufacturer or dealer, has the right to apply to the station for any assistance that comes within its province to render, and the station will respond so far as it lies in its power. All communications relating to agriculture, horticulture, plant or animal diseases, insects, etc., will be fairly considered, and, so far as possible, promptly answered.

The station farm and buildings are on the Williston road, adjoining the university grounds on the east. Electric cars pass within a quarter of a mile of the station building, at Colchester avenue and University place. Both the station and the farm have telephone connections and may be spoken from most telephone offices in the State.

☞Instructions for taking samples of fertilizers, fodders, milk, water, etc., will be sent on application. Parties desiring to send samples should first write for these directions. Many samples received are useless, being incorrectly drawn. Parcels by express, to receive attention, should be prepaid.

☞Copies of the reports and bulletins of the station are sent free of charge to any address upon application.

☞Address all communications, not to individual officers, but to the

EXPERIMENT STATION, BURLINGTON, VT.

TABLE OF CONTENTS.

PAGE.

Officers of the Station 2
Announcement 3
Table of Contents 4
Financial Reports for 1895-96 and 1896-97 6–7
Report of the Director 8–15
Publications on hand 15
Abstracts of Bulletins 17–27
Nos. 50, 51 and 52. Analyses of Commercial Fertilizers (1895), by J. L. Hills, B. O. White and C. H. Jones 17
No. 53. The Pollination of Plums, by F. A. Waugh 19
No. 54. Salad Plants and Plant Salads, by F. A. Waugh 20
No. 55. Apple Growing in Grand Isle County, by F. A. Waugh 21
No. 56. Orange Hawkweed, or "Paint-Brush," by L. R. Jones and W. A. Orton 21
Nos. 57, 58 and 59. Analyses of Commercial Fertilizers, by J. L. Hills, B. O. White and C. H. Jones 22
Report of the Chemists, by J. L. Hills, B. O. White and C. H. Jones ..28–33
Analyses of Miscellaneous Fertilizers 28
Analyses of Drinking Water 31
Miscellaneous Analyses 32
Pig Feeding, by J. L. Hills 34–43
History of Tests 34
Daily Rations, Gains, etc 36
Corn Meal and Shelled Corn 39
Skim Milk and Whey 40
Large and Small Quantities of Skim Milk 40
Proper Time to Market Pork 41
Financial Summary 42
Value of Skim Milk and Whey 42
Fertilizing Value of Feeds 42
Report of the Botanist, by L. R. Jones 44–74
I. Potato Diseases and Remedies 45
1. Potato Diseases as they occured in 1896 45
2. Studies upon Fungi associated with Early Blight 45
3. Tests of Various Forms of Bordeaux Mixture 52
4. The Effects of Disinfectants upon the Growth of Seed Potatoes 53
II. Apple Scald 55
III. Observations upon Oat Smut 59
IV. The Onion Mildew 61
1. Laboratory Studies upon the Fungus 61
2. Field Experiments with Fungicides 61
V. The Orange Hawkweed or "Paint-Brush" 62

Report of the Entomologist, by G. H. Perkins.....75–86

The Red Spider..... 75
Life History..... 76
Remedies..... 82

Report of the Horticulturist, by F. A. Waugh.....87–133

I. Problems in Plum Pollination..... 87
1. Self-Sterility, the Necessity of Cross-Pollination..... 87
2. Natural Adaptations for Cross-Pollination..... 89
3. Pollination Affinities of Varieties and Species..... 91
4. Blossoming Seasons of Plums..... 92

II. Classification of Plums..... 98

III. Preliminary Report on the Artificial Use of Enzyms in Germination..... 106

IV. The Preservation of Fruits by Vapor of Alcohol..... 111

V. A Report on the Occurence of the Cabbage-Root Maggot.... 116

VI. The Italian or "Orchid-Flowering" Cannas..... 119

VII. A New Grafting Machine..... 122

Appendix to Report of Horticulturist..... 124

Dairying, by J. L. Hills.....134–220

I. Studies in Methods of Experimental Feeding Trials..... 135
1. Summary..... 135
2. Introduction..... 137
3. Statement of Methods and Details of Conduct of Tests.. 139
4. The Proper Length of Feeding Periods..... 146
(*a*) Effect of Varying Period Lengths upon Quantity of Product..... 149
(*b*) Effect of Varying Period Lengths upon Quality of Product..... 150
5. The Relative Feeding Value of Two Rations of Equal Balance..... 161
6. Experimental Error in Feeding Tests..... 165
7. Practical Conclusions of Economic Value..... 167

II. Feeding Trials with Silages and Potatoes..... 169
1. Summary..... 170
2. Corn Silage vs. Silage made from Cowpeas and Soja Beans 171
3. Corn Silage vs. Potatoes..... 173

III. The Effect of Food upon the Quality of Butter..... 175
1. Summary..... 175
2. Effect upon Butter..... 176
3. Effect upon Churning..... 179

IV. Record of the Station Herd for 1895–96..... 181

V. Miscellaneous Fodder Crops..... 188

VI. Tests of Dairy Apparatus..... 191

VII. Appendix, containing condensed data pertaining to Articles I and II..... 193

Index..... 221

FINANCIAL REPORT

For the Fiscal Year Ending June 30, 1896.

Vermont Agricultural Experiment Station

IN ACCOUNT WITH

The United States Appropriation, 1895-6.

DR.

To Receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1896 as per Act of Congress, approved March 2, 1887 $15,000 00

CR.

	Abstract.	
By Salaries	1	$4,130 02
" Labor	2	5,547 20
" Publications	3	1,450 49
" Postage, stationery and telegrams	4	469 29
" Freight and express	5	229 08
" Heat, light and water	6	627 30
" Chemical supplies	7	267 92
" Seeds, plants and sundry supplies	8	71 18
" Fertilizers	9	69 50
" Feeding stuffs	10	122 26
" Library	11	176 67
" Tools, implements and machinery	12	173 03
" Furniture and fixtures	13	24 67
" Scientific apparatus	14	126 96
" Live stock	15	696 50
" Traveling expenses	16	180 59
" Contingent expenses	17	37 83
" Building and repairs	18	599 51
Total,		$15,000 00

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Vermont Agricultural Experiment Station for the fiscal year ending June 30, 1896; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000, and the corresponding disbursements $15,000, for all of which proper vouchers are on file and have been by us examined and found correct.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

Signed,

SEAL.

MATTHEW H. BUCKHAM,
CASSIUS PECK,
GARDNER S. FASSETT,
Auditors.

ATTEST, E. HENRY POWELL,
Custodian.

FINANCIAL REPORT

For the Fiscal Year Ending June 30, 1897.

Vermont Agricultural Experiment Station,

IN ACCOUNT WITH

The United States Appropriation, 1896-7.

DR.

To Receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1897, as per Act of Congress, approved March 2, 1887..... $15,000 00

CR.

Abstract.

By Salaries	1	$ 4007.83
" Labor	2	5090.66
" Publications	3	1556.45
" Postage, stationery and telegrams	4	254.53
" Freight and express	5	106.69
" Heat, light and water	6	908.83
" Chemical supplies	7	340.38
" Seeds, plants and sundry supplies	8	387.67
" Fertilizers	9	276.76
" Feeding stuffs	10	414.51
" Library	11	72.73
" Tools, implements and machinery	12	134.20
" Furniture and fixtures	13	40.95
" Scientific apparatus	14	142.64
" Live stock	15	175.00
" Traveling expenses	16	305.02
" Contingent expenses	17	105.87
" Building and repairs	18	679.28
Total,		$15,000 00

We, the undersigned, duly appointed Auditors of the Corporation, do hereby certify that we have examined the books and accounts of the Vermont Agricultural Experiment Station for the fiscal year ending June 30, 1897; that we have found the same well kept and classified as above, and that the receipts for the year from the Treasurer of the United States are shown to have been $15,000, and the corresponding disbursements $15,000, for all of which proper vouchers are on file and have been by us examined and found correct.

And we further certify that the expenditures have been solely for the purposes set forth in the Act of Congress approved March 2, 1887.

Signed,

MATTHEW H. BUCKHAM,
CASSIUS PECK,
GARDNER S. FASSETT,
Auditors.

SEAL.

ATTEST, E. HENRY POWELL,
Custodian.

REPORT OF THE DIRECTOR.

The present report nominally covers the work of a year and a half (Jan. 1, 1896-June 30, 1897) but in reality contains practically no data obtained prior to July 1, 1896. For several years each succeeding report has been brought as nearly as might be up to the date of writing (which is usually during the summer) in order to present promptly the results of finished work. Thus the date of the report has been no certain index of the time when the results it contained were reached. In order to avoid this condition and to bring about the coincidence of the report year with the fiscal year, and in accordance with the advice of the office of experiment stations of the department of agriculture, the report year will hereafter be considered as ending June 30.

PUBLICATIONS.

Ten bulletins and the ninth annual report, aggregating four hundred and sixteen pages of printed matter have been issued during the eighteen months and distributed to the entire mailing list. Six poster bulletins (four giving analyses of commercial fertilizers, one, directions for combating the army worm, and one descriptive of the orange hawkweed, with colored plate) for display in postoffices, and one newspaper bulletin (No. 13, on the Army worm) have also been issued. Abstracts of the regular bulletins are printed in this report on pages 17-27.

1896, March,	No. 50,	Analyses of Commercial Fertilizers, 8 pages.
April,	No. 51,	Analyses of Commercial Fertilizers, 12 pages.
May,	No. 52,	Analyses of Commercial Fertilizers, 24 pages.
August,	No. 53,	The Pollination of Plums, 20 pages.
November,	No. 54,	Salad Plants and Plant Salads, 16 pages.
December,	No. 55,	Apple Growing in Grand Isle County, 16 pages.
December,		Ninth Annual Report, 240 pages.
1897, February,	No. 56,	Orange Hawkweed or "Paint Brush," 16 pages.
March,	No. 57,	Analyses of Commercial Fertilizers, 16 pages.
April,	No. 58,	Analyses of Commercial Fertilizers, 16 pages.
May,	No. 59,	Analyses of Commercial Fertilizers, 32 pages.

Several of the back reports and bulletins are out of print. Parties having spare copies of any of the publications noted in the following list would confer a favor by returning the same, thus enabling the station to comply with requests from libraries, etc. Postage will be refunded.

Reports I, II, IV, VI, VII, VIII.

Bulletins 1-8, 10-12, 14-16, 19, 31-34, 36-39, 42.

A list of the back reports and bulletins which are in print and are available for distribution is given on pages 15 and 16 at the close of the director's report.

CHANGES IN STATION STAFF AND EQUIPMENT.

Prof. F. A. Waugh, formerly of the Oklahoma and Kansas stations and Mr. C. H. Jones of the Massachusetts station were made respectively horticulturist and assistant chemist early in 1896. Mr. D. D. Howe resigned the position of farm superintendent Feb. 1, 1897, and was succeeded by Hon. Cassius Peck of Brookfield. It is gratifying to note that no change has occurred in the scientific staff of the station for three years except such as has added to and strengthened it.

The botanical laboratory was removed to new and improved quarters in the Williams Science Hall during the summer and the chemical laboratory was thoroughly overhauled, repaired and reconstructed during the fall and winter. Considerable new permanent apparatus has been placed in each of these laboratories. The dwelling house of the farm superintendent has likewise been repaired.

RELATION OF THE STATION TO THE PUBLIC.

The station acts as a bureau of information upon matters of agricultural interest in a four-fold manner:

1. By the publication and distribution of the results of experiments in the form of bulletins and reports.
2. By articles appearing in the agricultural and general press.
3. By direct correspondence with individuals of all classes, particularly with farmers.
4. By the personal contact of members of the station staff with the farming community at institutes, fairs, by visits, etc.

Mailing List. Although the station mailing list is revised biennially through returns from local postmasters, it is yearly increasing in size owing to new calls. It could readily be expanded to much larger size by indiscriminately adding addresses variously obtained. It is deemed wise, however, to restrict the distribution to such parties as show enough interest in the station work to request its publications.

Motives of economy as well as conservatism prompt the station to be chary in unduly increasing the size of its mailing list. Editions of from 8,500 to 9,000 have to be printed in order to supply the present list and to leave a moderate number on hand to meet subsequent demands. The printing bill of the past two years has averaged over $1500 annually, a very serious drain upon the limited resources of the station. The more the work, the better its appreciation by the public, the greater the cost of diffusing the results. In most states the station publications become a part of the state printing. If the Vermont station enjoyed the privilege accorded to so many of its sister stations it might enable greater liberality in distribution and would certainly afford wider opportunities for usefulness. It is the popular idea that the station is supported by state funds, which is not the fact. Its income is obtained from a United States appropriation (derived from the

sale of public lands), from the sale of produce of its farm, and from the fees for licensed fertilizers. *No state funds are appropriated to the station for any purpose whatsoever.*

Correspondence. The letter press-copy books of the past year show a use of about 2500 letter sheets, the equivalent of considerably more than 4000 letters, a large part of which were written in answer to inquiries from farmers on agricultural topics of various kinds. This mass of correspondence, and the not infrequent study and research required for proper answer make heavy inroads upon the time of the director and of several members of the station staff. It is, however, a legitimate branch of station work and is thought to be directly helpful to the farming interests of the state.

Personal contact. In few ways can station work and experimental results be better brought home to farmers than by their visitation on the station grounds, the attendance of station workers upon farmers' institutes, etc. Visitors are always welcome on week days to inspect the station farm, buildings, and stock. For several years a grange basket picnic has been yearly held upon the station grounds, which has been generously attended. The station director has been an active member of the State Board of Agriculture for eleven years and has addressed from 20 to 40 institutes yearly in all parts of the state, while other members of the staff have been frequently called upon for similar service. This work, while time-consuming, proves, it is thought, mutually helpful to the farmer and to the station worker, enabling the one better to comprehend the work which is being done and the other to appreciate more clearly the needs of the farming community.

Miscellaneous analytical work. A large and yearly increasing amount of work is put upon the handling of miscellaneous materials of an agricultural nature sent by the citizens of the state for free analysis, in accordance with section 263 of the Vermont Statutes. When this law was passed in 1886 an appropriation was made for its enforcement, which was withdrawn in 1890, the obligations, however, being maintained. Most of the stations which, like that of Vermont, receive no state aid, decline to handle this class of work. The resources of the Vermont station, derived entirely from the United States government and from the sale of farm products, are already insufficient properly to carry forward all the lines of experimental work which it would be desirable to inaugurate. It may soon become a serious question whether, to use the phraseology of the law, "time and means will permit" the further continuance of a line of work which is of but temporary value, which is, as a rule, in the interests of private rather than of the public good, and whether the greatest good of the greatest number does not demand the concentration of the energy of the station officers upon more purely experimental work.

WORK OF THE YEAR.

The lines of work pursued during the past year have been similar to those previously followed, with the notable addition of investigation in horticul-

ture. New problems in divers lines are not infrequently urged upon the station officers by the farmers of the state for investigation, which are with reluctance declined. The limited resources of the station and an adherence to the policy of strengthening, so far as possible, the more important classes of inquiry now in hand prevent the inauguration of much new work. The tendency in American station work is towards greater specialization, the concentration of the work of individual stations upon relatively a small number of problems, upon thoroughly answering some rather than half answering several questions. This need not prevent the farmer from obtaining wide information. The publications of other stations are usually sent upon request. The "farmers bulletins" and other publications of the Department of Agriculture at Washington are issued in large editions, they epitomize station work the world over, and are generally sent free upon request. There is no reason why the Vermont farmer should feel himself confined to the publications of this station when the results of the research of a hundred stations are at his command.

Concise statements of the main results of the experimental inquiry of the year will be found in the following pages under appropriate headings. So far as possible each successive article is summarized.

COMMERCIAL FERTILIZERS.

Section 4355 of the Vermont Statutes places the control of the sale of commercial fertilizers in the hands of the state treasurer and the experiment station. It likewise prescribes the manner of publication, requiring monthly bulletins during the fertilizer season. Bulletins 50-52, 57-59 have contained the results of the work of the springs of 1896 and 1897. Readers are referred thereto for the analyses of the various brands.

Each year five-sixths of the total number (110 and 134) of brands sold were essentially equal to or better than their guarantees. But one brand was seriously deficient in plant food in 1896, while in the latter year seven brands, a part of the output of three companies contained much less plant food than was guaranteed. The average quality of the goods was somewhat better than in 1895. Average goods sold for the same price in 1896 and for less in 1897 than in 1895. Plant food was cheaper in 1897 than ever before in the history of the trade, yet cost at the consumer's depot 50 per cent. more than "valuation," one dollar in every three invested paying for the cost of manufacture and sale. As a rule the lower the grade of the goods the greater the cost of a pound of actual plant food. Many Vermont farmers are practicing "home mixing" to advantage, finding it an economical and satisfactory method for the purchase of plant food.

PIG FEEDING.

In a series of experiments with twelve pigs (1) corn meal proved better than whole corn; (2) whey and bran better than skim-milk liberally fed with corn, and equal to skim-milk moderately fed with corn; (3) economy of pro-

duction favored medium rather than large amounts of skim-milk; (4) skim-milk proved worth but 15 cents and whey but 9 cents a hundred.

PLANT DISEASES.

Comparatively little late blight and rot of potatoes was observed in 1896, but there was relatively large destruction of foliage by improper use of paris green and by "tip burn." The true blights succumb to bordeaux mixture properly applied, but arsenical poisoning and physiological troubles must be met in other ways.

Further study has served yet more clearly to differentiate between the Alternarias found upon dying potato leaves and to determine their relations to the maladies affecting the crop.

Standard bordeaux mixture proved no better upon potatoes than did a mixture made with half the quantity of lime but is thought as a rule to be safer to use though sometimes less convenient. Bordeaux powder was found as in previous years to be practically a failure.

Disinfection of seed potatoes with corrosive sublimate did not retard germination if performed 45 or more days before planting, but when carried out just prior to planting it seriously affected the early growth. Disinfection with formalin had no such injurious effect but if anything seemed to stimulate growth.

A serious affection of Greening apples known as "scald" was found on investigation and through consultation with orchardists and observers elsewhere to be due both to orchard and storage conditions. Perfect maturity, vigorous trees, good storage ventilation, and sweating prior to barrelling were found to retard the inception of the disease.

The disinfection of smut-free seed oats tended to lessen the crop, instead of bettering the yield as claimed by some observers.

Experiments on the onion mildew gave no results owing to its comparative absence in the field upon which the fungicides were used. Full strength bordeaux mixture injured the leaves.

THE ORANGE HAWKWEED OR "PAINT BRUSH."

This serious weed pest is rapidly spreading over the state. It is propagated by seed and by stolons. Its prominent characteristics are flame-red flower clusters, a tall, hairy stalk and a low rosette of hairy leaves. Clean cultivation will eradicate it. Salt at the rate of a ton and a half to the acre will kill it out and will seldom injure the grass. It is strongly urged that its further spread be prevented.

THE RED SPIDER.

The mite ordinarily but incorrectly known as the "red spider" is an insect which has long troubled greenhouse plants as well as out-door ornamentals, orchards, nurseries, etc. Although long and well known, its life history has been hitherto but imperfectly understood. The late Dr. J. H. Worcester undertook a long series of careful investigations, partly in collabora-

tion with the station entomologist, the results of which are now available for publication. As a result of these observations it appears that the egg hatches in warm weather in about a week; that there are three moults occupying a week; that if males be present impregnation follows the first moult, if not, unfertilized eggs are laid which produce only males; that males are smaller, of different shape, and often lighter in color than the females; that from fifty to one hundred eggs are laid by one female; that one impregnation serves for life. In the matter of remedial treatment the method commonly believed most efficient, the vapor of water, was found useless; water, either as a stream from a hose nozzle, applied by sponge, or as suds, has proved effectual, as has likewise kerosene emulsion and sulphur fumes. It was found peculiarly difficult to kill the eggs. Repeated applications only appeared entirely successful.

PLUM POLLINATION.

Investigations in the large orchard of Mr. J. W. Kerr, of Denton, Md., covering over 6,500 observations, show that for all practical purposes all classes and varieties of native plums are absolutely self-sterile, and that Japanese plums are sometimes quite self-sterile, cross-pollination benefiting nearly all varieties. Abnormalities in plum pistils in blossoms received from a large number of points were found to be quite frequent, probably in many cases seriously affecting fruitage. The causes influencing defectiveness were found to be the physiological character of the plant, the age and health of the tree, and the storage of food materials rather than stress of weather, etc. Several practical observations were made touching the availability of varieties for cross-pollination, and a long series of comparisons of blossoming periods are charted as aids in the study of pollination adaptabilities.

CLASSIFICATION OF PLUMS.

A careful classification of the native plums was made, which it is hoped will be a help to a better understanding of their relationships. The varieties studied are divided into the following groups: Domestica, Japanese, Americana, Nigra, Miner, Wayland, Wildgoose, Chicasaw and Marianna, with some remarks upon groups of less importance.

ARTIFICIAL USE OF ENZYMS IN GERMINATION.

As a result of a large number of tests of enzyms or unorganized ferments as aids in germination, the following tentative generalizations were made: In some cases the percentage of germination in seeds is greatly increased by soaking for several hours in a solution containing some active enzym or enzyms; the vigor of the young plantlets is often enhanced at the same time; within limits these beneficial effects increase with the strength of the enzym solution; diastase, either from malt or from various commercial preparations, seems to be most useful; tomato seeds seem to respond especially well to the action of diastase.

PRESERVATION OF FRUITS BY VAPOR OF ALCOHOL.

A series of tests made under various conditions with several kinds of fruit indicated that an appreciable quantity of the vapor of alcohol in a closed space will prevent more or less the growth of the fungi and bacteria which usually hasten decay. If present in a considerable quantity their development may be wholly prevented for several days or weeks. But in this case the fruits, especially those with soft flesh, absorb enough alcohol to render them very disagreeable to the taste. The fruit also deteriorates in color and texture. Although the growth of fungi and bacteria is prevented, other processes of decay seem to be hastened. The method seems to be best adapted to the preservation of grapes. It is thought that this method might be put to practical use in occasional cases for the preservation of some other fruits for a very short time.

THE CABBAGE-ROOT MAGGOT.

This insect ravaged the station experimental plats in the summer of 1896. The only very effective method of combating its attacks is preventive in its nature, and consists in protecting the plants by a small piece of tarred paper put about the stem on top of the ground, in order to prevent the female from laying her eggs at that point. Crop rotation is also advisable.

THE ITALIAN OR "ORCHID-FLOWERING" CANNAS.

These new cannas, the result of crossing the French dwarf cannas with *Canna flaccida*, have recently been introduced. Trials of several varieties at this station indicate that they cannot become as widely useful as the French dwarfs, but are notwithstanding highly desirable additions to the list of ornamental plants.

A NEW GRAFTING MACHINE.

A French grafting machine was tried in an experimental way, and judged to be a pointed suggestion to the inventive horticulturist rather than an accomplished practical success.

FEEDING EXPERIMENTS WITH MILCH COWS.

Extensive feeding tests were made, to determine the following points:

(*a*) What length of feeding period is most likely to give reliable results?

(*b*) What variations in production are to be expected from different rations containing essentially the same amounts of the various nutrients?

(*c*) What is the extent of the probable error inherent in feeding experiments due to the individuality of the animals used, or to other causes?

(*d*) The relative feeding values of rations containing Atlas gluten meal, cottonseed and linseed meals, corn and bran.

(*e*) The relative feeding values of rations containing corn silage and cowpea and soja bean silage, and of rations containing corn silage and potatoes.

(*f*) The effect of these various rations upon the character of the butter and upon the churning of the cream.

The results of these trials cannot be briefly expressed. They are condensed as closely as possible upon pages 135-137 (*a-d*), 170 (*e*) and 175 (*f*) of this report, to which summaries the reader is referred.

RECORD OF THE STATION HERD FOR 1895-96.

For several years the record of production of milk and butter by the station herd has been published. The cost of production has been carefully considered also during the past year. The cows averaged 324 pounds of butter, costing for food 13.8 cents per pound, selling for 23 cents per pound. The relative ranks in production and economy of production of the same cows in two successive years were frequently quite different.

MISCELLANEOUS FODDER CROPS.

Of several leguminous crops, crimson clover and alfalfa proved failures, flat pea somewhat doubtful, vetch and oats inferior to peas and oats, green and black soja beans successful. The various millets again proved good forage plants. Two varieties of Kafir corn grew well but did not mature seed; they seemed in no way preferable to indian corn in this climate. White mustard, a cover crop, was found to be very rich in plant food.

TESTS OF DAIRY APPARATUS.

Incidental trials of several farm separators tend to confirm the station in the belief that there is not of necessity, any one make that is "best" in all points; that machines of all the more prominent makes are capable of doing a good grade of work when properly handled; that, since good skimming is the rule, other points, such as initial cost, durability, probable repair bills, ease of operation, etc., are now more important; and finally, since flaws may occur in individual machines of any make, that agents' claims and records of other machines of the same make are of less value, touching the quality of skimming than is the analysis of the skim-milk of the individual machine offered. Many farmers in this state have bought separators, on the condition that the skim-milks should be submitted to the experiment station for analysis, purchase to follow its favorable, and rejection, its unfavorable report. The buyer thus has, free of expense, the advantage of the advice of disinterested experts, which, moreover, is given in ignorance of the kind of machine under trial.

PUBLICATIONS ON HAND.

The Station has issued to date (October, 1897), including the present number 10 annual reports and 59 bulletins. Many of these are out of print. The following numbers are in print, and will be sent on request without charge as long as the supply lasts:

1888, April. No. 9, Smut in Oats, Insecticides and Fertilizers..... 8 pages
November. No. 13, Methods of Cutting and Planting Potatoes; Fertilizer Analyses..... 12 pages

1889, October.	No. 17, Test of Dairy Cows at Vermont State Fair	16 pages
	Third Annual Report	172 pages
1890, January.	No. 18, Pig Feeding	20 pages
May.	No. 20, Analyses of Fertilizers Licensed for Sale in the State of Vermont for the year 1890	16 pages
September.	No. 21, A New Milk Test; Testing milk at Creameries and Cheese Factories; Notes for the Laboratory	32 pages
October.	No. 22, Test of Dairy Cows; Home vs. Fair Grounds	12 pages
1891, March.	No. 23, Analyses of Fertilizers Licensed for Sale in the State of Vermont for the year 1891	16 pages
May.	No. 24, Potato Blight and Rot	16 pages
June.	No. 25, The Bounty on Maple Sugar	4 pages
September.	No. 26, Maple Sugar	24 pages
	Fifth Annual Report	168 pages
1892, January.	No. 27, Tests of Dairy Apparatus	12 pages
April.	No. 28, Plant Diseases	24 pages
May.	No. 29, Analyses of Fertilizers Licensed for Sale in the State of Vermont for the year 1892	12 pages
June.	No. 30, The Result of the Bounty on Maple Sugar	8 pages
1893, May.	No. 35, Analyses of Fertilizers Licensed for Sale in the State of Vermont for the year 1893	16 pages
December.	No. 40, Spraying Potatoes	20 pages
1894, May.	No. 41, Analyses of Commercial Fertilizers	16 pages
July.	No. 42, Bovine Tuberculosis	54 pages
November.	No. 43, Household Pests	8 pages
December.	No. 44, Spraying Orchards and Potato Fields	28 pages
1895, March.	No. 45, Analyses of Commercial Fertilizers	8 pages
April.	No. 46, Analyses of Commercial Fertilizers	16 pages
May.	No. 47, Commercial Fertilizers	40 pages
October.	No. 48, Gluten Feeds and Meals	20 pages
December.	No. 49, Potato Blights and Fungicides	24 pages
1896, March.	No. 50, Analyses of Commercial Fertilizers	7 pages
April.	No. 51, Analyses of Commercial Fertilizers	12 pages
May.	No. 52, Analyses of Commercial Fertilizers	24 pages
August.	No. 53, The Pollination of Plums	20 pages
	Ninth Annual Report	240 pages
November.	No. 54, Salad Plants and Plant Salads	16 pages
December.	No. 55, Apple Growing in Grand Isle County	16 pages
1897, February.	No. 56, Orange Hawkweed or "Paint Brush"	16 pages
March.	No. 57, Analyses of Commercial Fertilizers	16 pages
April.	No. 58, Analyses of Commercial Fertilizers	16 pages
May.	No. 59, Analyses of Commercial Fertilizers	32 pages
	Tenth Annual Report	224 pages

ABSTRACTS OF BULLETINS.

Bulletins Nos. 50-51-52—Analyses of Commercial Fertilizers—(1896.)*

By J. L. Hills, B. O. White and C. H. Jones.

SUMMARY.

I. The trade values of fertilizing ingredients in mixed goods this year are 13½, 15 and 14 cents per pound for nitrogen in nitrates, ammonia salts and in organic forms respectively; 5½, 5 and 2 cents per pound for soluble, reverted, and insoluble phosphoric acids; 5 and 4½ cents per pound for potash as sulphate and as muriate.

These trade values do not represent the proper selling prices of mixed goods at the point of consumption, but are the retail cash prices of the various fertilizing ingredients in the large markets, unmixed but ready for use. They do not include freight, cost of manufacture, storage, commissions, etc. They stand in no necessary relation to the profits derived from the use of the goods, but have an almost purely commercial significance.

The Station has analyzed samples of 110 distinct brands of fertilizers, all taken this spring from dealers' stocks and all 1896 goods. This is 18 more than were analyzed in 1895 and 57 more than in any year previous to that time.

Of 110 brands analyzed, 70 (nearly two-thirds) were above guarantee throughout. Of the 40 deficient brands, 21 were but slightly short in a single ingredient, but three were lacking in two ingredients, and but one was seriously deficient. Practically five-sixths of the brands sold in Vermont in 1896 were equal to or better than guarantees, and 99 per cent. are commercially equivalent to guarantees. In no year previous have so good results been obtained.

II. The average composition of 71 brands sold in Vermont in 1895 and 1896 shows a slightly better quality this year and an increase of forty cents in valuation. Prices are a little less, but have not dropped in proportion to

*The analyses of the individual brands have been reprinted in years past in the abstracts. Owing to the rapid increase in the number of brands sold in the state during the past few years, and to the fact that the present report covers a year and a half's work, the amount of page room necessary to give these figures is excessive, the tables alone covering 19 pages. It has been deemed best therefore, to omit reprinting the analyses of the various brands, and to refer readers interested therein to the bulletins (52 and 59) which will be sent to any address upon application.

the lessened cost of crude stock. The increase of cost over valuation of the average goods is 57 per cent., the highest since the Station begun to execute the State law ten years ago. Yet plant food was as cheap in 1896 to the farmer as it had been in any year previous. If former prices were fair, however, it should have been cheaper than ever before.

SELLING PRICES AND STATION VALUATIONS.

The office of the Experiment Station under the law is simply to find whether the compositions of the various mixed goods sold correspond with their guarantees. "Station valuations" furnish a common basis on which to compare different brands, and enable buyers to note whether prices asked are warranted by values contained.

The comparison of Station valuations and selling prices of the brands analyzed in 1896 is instructive and shows that a dollar spent for the average low priced brands (below $30) bought 60.4 cents' worth of plant food at retail sea-board prices ; a dollar spent for average medium priced goods ($30 to $35), 64 cents' worth ; and a dollar spent for average high grade goods (above $35), 68.7 cents' worth.

An example taken from the tables in the bulletin may make still plainer the necessity of carefully studying the relation between guarantees and selling prices. One manufacturer offered in 1896 in Vermont a brand containing 0.75 per cent. nitrogen, 8 per cent. available phosphoric acid and 1 per cent. potash. Its average selling price at several points was $27.30. For $2.20 more the same manufacturer offered a brand containing three times as much nitrogen and potash and the same amount of phosphoric acid. In the first brand 58 cents' worth of fertility at sea-board prices were bought for a dollar, in the second, 80 cents' worth. Yet more striking results may be obtained by comparing the products of rival manufacturers, extremes being 48 cents' and 81 cents' worth bought for a dollar.

AVERAGE COMPOSITION OF 71 BRANDS OF FERTILIZERS AS SOLD IN 1895 AND 1896.

Name of Ingredient.	1895.		1896.	
	Pounds in a hundred.	Valuation at 1896 Prices.	Pounds in a Hundred.	Valuation at 1896 Prices.
Nitrogen	2.17	$6.08	2.25	$6.30
Soluble Phosphoric Acid	5.98	6.58	5.53	6.08
Reverted Phosphoric Acid	2.46	2.46	3.20	3.20
Insoluble Phosphoric Acid	2.54	1.02	2.36	0.94
Available Phosphoric Acid	8.44		8.73	
Total Phosphoric Acid	10.98		11.09	
Potash	3.35	3.01	3.38	3.04
Total valuation per ton		$19.15		$19.56

The above table shows but little change. There is slight increase in each of the three ingredients, and the increase in valuation is forty-one cents or a little over two per cent. The average goods of the past two years contain less plant food than those of previous years, are worth less and sell for less, but not as much less as they should considering the decrease in quality and the lower cost of crude stock.

The selling price of the average commercial fertilizer sold in Vermont has decreased every year until 1896, when it has remained stationary. The inspection of 1896 included many high grade, high priced goods which served to raise this figure. A comparison of the selling prices for 1895 and 1896 of the brands most commonly used in the State shows an average decrease of 32 cents per ton in selling price this year.

The high percentage of increase of cost over valuation during the past three years should be noted. The cost of mixed goods has decreased, but proportionately the cost of crude stock has lessened still more. The large buyer may well consider whether he can afford to pay 57 per cent. of the seaboard value of the unmixed chemicals to the manufacturer for mixing, bagging, freighting and selling the goods. The home mixing system is successfully practised by many and has much to recommend it. Notwithstanding these facts a dollar purchases as much plant food this year as at any previous time in the history of the trade in the State.

Bulletin No. 53—The Pollination of Plums.

By F. A. Waugh.

SUMMARY.

I. Plums are very uncertain in setting fruit. A part of this uncertainty seems to be due to lack of proper cross-pollination. To secure cross-pollination plums of different varieties should be closely planted, or scions of different varieties should be set into the tops of trees which do not bear satisfactory crops of fruit.

II. Cross-pollination is an important factor in determining the crops of pears, apples, grapes, strawberries and other fruits.

III. Cross-pollination in plums is provided for by several natural adaptations, especially by the defectiveness of flower parts and by the sterility of certain varieties toward their own pollen.

IV. American varieties of cultivated plums have arisen from several distinct botanical species. These varieties retain more or less the characters of the parent species, and thus may be judged to some extent by their parentage. It is thought that the botanical relationships of varieties will prove to be the best guide to their affinities in cross-pollination.

The economic characters of these groups may be generalized as follows:

European; (Prunus domestica); hardy; best and most salable fruit; perfect pistils; not good pollen bearers.

Myrobolan; used as stock, but losing in favor, being supplemented by Marianna and Americana varieties.

Japanese; comparatively new; relative value uncertain; several varieties practically hardy.

Americana group; the Western wild plum; very hardy; fruit good but inferior to European; good stocks; very delicate sexually; usually requires cross-pollination. Eastern forms (var. nigra) are even more hardy than Western forms; range further north; stronger pistils; weaker pollen bearers.

Wild Goose Group; about as hardy as Japanese plums; thought to need cross-pollination and to be weak pollen bearers.

Marianna; probably a hybrid; sexually weak; uncertain bearer; chiefly used as stock.

Chicasaw; of Southern origin; doubtfully hardy in Vermont; many prolific and desirable varieties.

V. Eminent horticulturists and botanists agree in the general desirability of cross-pollination in plums.

VI. Although we have gained some knowledge as to the pollination of plums, there are yet many questions of practical importance and theoretical interest open to investigation. It is hoped that this bulletin will call attention to some of these unanswered questions and direct the reader to further observation and reflection.

Bulletin No. 54—Salad Plants and Plant Salads.

By F. A. Waugh.

Few farmers' families get as much of their living from their gardens as they should. Salad plants are especially neglected. Lettuce is the only true salad plant popular in this country, and it is not at its best when served in the usual way with sugar and vinegar. Garden cress is one of the best salad plants, and one of the easiest to grow. Seeds sown out of doors like radishes make edible plants in three to four weeks. There are only one or two varieties extant in America. Upland cress and water cress are very different plants, and have less general value. White mustard, corn salad, endive, chicory, and other plants are often used for salads, and each has some value. For boiled salads, or "greens," Swiss chard, spinach, endive, and kale are valuable and easily grown.

The simplest and best way to make a salad is to dress the fresh, dry leaves selected with a pinch of salt and a very small quantity of vinegar and salad oil. Sweet cream can be substituted for the oil. Many other dressings are described in the cook books, but the simpler are usually the better.

Bulletin No. 55—Apple Growing in Grand Isle County.

By F. A. Waugh.

SUMMARY.

I. Grand Isle County, Vermont, is increasingly devoted to commercial apple growing. The success already achieved encourages further extension of the industry. The methods in vogue have had the proof of experience, and are presumably worth adoption in other parts of the State.

II. The crop of 1896 has been larger than any previous one. Careful computation shows it to be 40,424 barrels of marketable apples. The number of bearing trees is 34,885; and of trees still too young to bear, 17,229.

III. Sandy or gravelly soils are preferred, without much reference to slope. Budded nursery stock, two or three years old, is chosen for planting, though some prefer setting native or hardy stock and making a top by grafting. All commercial orchards are systematically cultivated. Barnyard manure is used in orchards with and without fertilizers containing more phosphoric acid and potash. Windbreaks are found valuable. Various methods of securing protection from winds are in vogue. Spraying is an accepted practice; apparatus and methods vary. Top grafting is easily done in spring, and is frequently practiced. Favorite varieties are Northern Spy, Rhode Island Greening, Baldwin, Fameuse, Talman's Sweet, Pound Sweet, Golden Russet, Ben Davis, Yellow Belleflower and Arctic.

Apples are picked directly into barrels and are usually sent to market early. Some are held in storage. On the whole, paying prices are realized.

Bulletin No. 56—The Orange Hawkweed or "Paintbrush."

By L. R. Jones and W. A. Orton.

SUMMARY.

I. The orange hawkweed or "paint brush" is the worst weed known in certain portions of Vermont and threatens to invade other parts of the State unless precautions are taken.

It is easily recognized by its peculiar hairy leaves and stem, and especially by its conspicuous orange-red blossoms.

II. It is a native of the mountainous regions of Europe and has been introduced into this country as a garden flower. It appears to have become well established in this State within twenty-five years and has spread most actively within fifteen years. It is most troublesome in the northwestern counties.

It seems capable of rapid adaptation to varying conditions and thrives almost equally well in all soils from sandy loam to heavy clay, and at all altitudes. Its further spread may therefore be expected.

III. It is most troublesome in permanent grass lands, such as lawns, roadsides and hill pastures. When thoroughly established in the latter it is extremely difficult to eradicate it.

It is a perennial and propagates itself rapidly both by runners and by seeds.

IV. This weed may be subdued by clean culture where this is practicable.

It is also very quickly killed by salt, which should be applied dry, scattered broadcast so as to reach the leaves of all plants, at the rate of eighteen pounds per square rod or a ton and a half per acre. This amount of salt has proved beneficial to grass, nearly doubling its yield. Salt suitable for the purpose costs from $3.00 to $5.50 per ton. It is urged that salt be used to kill the weed in all cases where only a small amount of it occurs, since the quick and complete destruction of the weed in such cases is of the utmost importance in the prevention of its wider spread.

VI. Information is desired from those having experience with this weed and correspondence is invited concerning other weed plants.

Bulletins Nos. 57-58-59—Analyses of Commercial Fertilizers—(1897).*

By J. L. Hills, B. O. White and C. H. Jones.

SUMMARY.

I. Trade values per pound of fertilizing ingredients in mixed goods; nitrogen in nitrates, ammonia salts, and in organic forms, 14, 13½ and 14 cents; soluble, reverted and insoluble phosphoric acids, 5½, 5 and 2 cents; potash, sulphate and muriate, 5 and 4½ cents. The "station valuation" does not represent the proper selling price in Vermont, but shows the retail cash cost of amounts of plant food equal to that contained in a ton of the individual brand, in unmixed, standard raw materials at the seaboard. Its significance is not agricultural but is almost purely commercial.

II. The Station has analyzed samples of 134 distinct brands, the output of 20 companies, all drawn from dealers' stocks and (with one exception) this year's goods. The number of brands sold in the State is rapidly increasing. Two-thirds of the total number were above guarantee in every respect and five-sixths were essentially equal to or better than guarantee. Sixteen brands fell short more than 0.20 per cent. in one, five were lacking in two ingredients and one was below guarantee throughout. In one of the five cases both ingredients were seriously deficient. Shortages in one

*See foot note at bottom of page 17.

ingredient were not made good (commercially) by excess of other ingredients in seven brands, a part of the output of three companies. In one case analysis and guarantee were found to be widely apart in two ingredients, although an equivalent of plant food was given. Ninety-four per cent. of the entire number of brands contained the commercial equivalent of their guarantees. One hundred and two brands were guaranteed (directly or inferentially) to contain potash as sulphate, a claim which was verified in but 17 cases. The application of the pepsin digestion and Hayes-permanganate distillation methods to the several brands indicated that the class of materials furnishing organic nitrogen was almost without exception above reproach.

The average "valuation" was $19.47 and the average selling price $29.19, an advance of 50 per cent. over valuation. One dollar out of every three invested in fertilizers paid for cost of manufacture and sale. A dollar spent for average low priced goods (below $29) bought 64 cents' worth of plant food ; a dollar invested in average medium grade brands ($29 to $35), 69 cents' worth ; and a dollar paid out for average high priced goods ($35 and upwards), 72 cents' worth.

III. The average composition of the goods has not varied materially from that of last year. Selling prices are lower and plant food cheaper than ever before in the history of the trade.

Station Analyses and Guarantees.—The following table shows the number of brands sold by the different companies licensed in the State, the number of guarantees (nitrogen, available phosphoric acid, potash) made by each, and the number of failures to make the same good (within 0.20 per cent.) as judged by the analyses of the samples taken by the Station.

Name of Company.	Number of Brands.	Number of Guarantees.	Number of Guarantees not made good.
American Fertilizer Co	4	12	1
Boston Co-operative Buyers Association	5	15	5
Bowker Fertilizer Co	19	56	0
Bradley Fertilizer Co	14	42	2
Clark's Cove Fertilizer Co	3	9	0
Cleveland Dryer Co	8	24	0
E. Frank Coe Co	14	41	5
Crocker Fertilizer and Chemical Co	6	18	1
Cumberland Bone Phosphate Co	5	15	0
Great Eastern Fertilizer Co	4	11	0
Lister's Agricultural Chemical Works	9	25	0
Lowell Fertilizer Co	5	15	4
Pacific Guano Co	3	9	0
Parmenter & Polsey Co	2	6	0
Quinnipiac Co	8	24	2
Read Fertilizer Co	8	23	1
Russia Cement Co	4	12	0
Standard Fertilizer Co.	4	12	0
Henry F. Tucker Co	3	9	1
Williams & Clark Fertilizer Co	6	18	1
Total	134	396	23

Availability of Organic Nitrogen.—The Hayes acid-permanganate and pepsin digestion methods for the determination of the availability of the organic nitrogen were used on all brands. The latter method as a rule gave higher results than the former, but there was usually parallelism.

The samples showing less than sixty per cent. availability by either method were tested with iron phosphate dissolved in glacial phosphoric acid as suggested by Dabney and by Lindsey. The results were, however, negative in every case, no certain indications of the use of leather being found. It is safe to say that a nitrogen availability below 50 is cause for suspicion. Fortunately but three brands seem to be beyond the dead line, which would indicate the probability that the trade in general uses the better grade of materials yielding organic nitrogen.

Multiplicity of Brands.—The rapid increase in the number of brands on sale in the State has been noted elsewhere. All farm requirements would be as well met by thirty as by one hundred and thirty brands, particularly when, as is often the case, several "brands" are shovelled from the self-same bin.

The names of the various goods seldom offer any clue to their character. The word "bone" does not necessarily imply that the goods contain any bone. Neither does the fact that the words "potato" or "corn" appear upon the bags certify to the character of the goods. Competition more than popular demand has given rise to this condition which is confusing rather than helpful to the farmer.

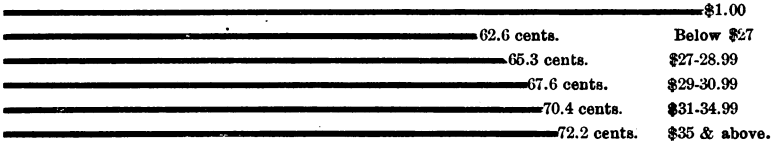
Selling Prices and Station Valuations.—It often occurs that buyers consider valuation rather than analysis. This is wrong; a brand may value high yet be ill adapted to a certain soil or crop. In so far as the valuation system tends to distract the buyer's attention from the composition of the goods and its fitness for his special needs, it fails in its mission.

Selling prices necessarily exceed valuations, since the latter do not include necessary and legitimate charges accompanying the manufacture and sale of mixed goods. On the average one dollar out of every three spent for commercial fertilizers in 1897 in Vermont went to pay for mixing, bagging, freighting and selling the goods.

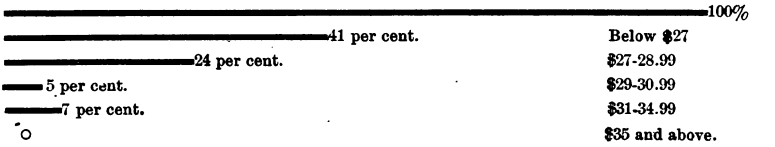
The relation of the selling price to the value of the plant food contained is of quite as much importance as that of a manufacturer's exact compliance with a guarantee statement of his own choice. It is a matter, however, which no law can touch; no statute can regulate the price at which commercial fertilizers shall sell or the relation of that price to the value of the goods.

It is to be hoped that the "unit system" of purchase which is in vogue among the manufacturers in the purchase of raw materials may come into use in the sale of mixed goods. Under this system the purchaser would buy where he can get *plant food* the cheapest, not, as now too frequently happens, where he can get the most *weight*, be it plant food or not, for his money.

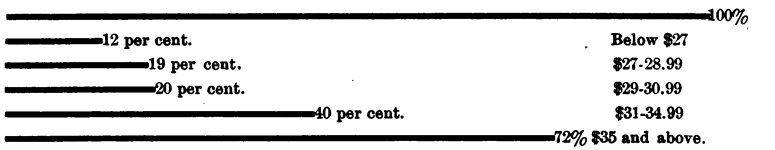
The following graphic illustration comparing selling prices and valuations of average goods of different selling prices is very suggestive. The relative lengths of the following lines indicate the average cents' worth of plant food at retail seaboard prices bought for a dollar at consumer's depot in brands selling between prices given :



The following lines shows the per cent. of the total number of brands in each group selling between the prices given which contain *less than* 60 *cents' worth of plant food* at retail seaboard prices for the dollar invested at the consumer's depot.



The final set of lines shows the per cent. of the total number of brands in each group selling between the prices given which contain *more than* 70 *cents worth of plant food* at retail seaboard prices for the dollar invested at the consumer's depot.



Translating figures and lines into words, it should be noted that :

(1) *A dollar spent for average low priced brands* (*below* $29) *bought* 64 *cents' worth of plant food at retail seaboard prices; a dollar invested in average medium grade goods* ($29 *to* $35), 69 *cents' worth; and a dollar paid out for average high class goods* ($35 *and upwards*), 72 *cents' worth.* A dollar bought 86 cents' worth of plant food in one brand sold in the State this year, while it purchased but 50 cents' worth in another brand. *One-fifth* of the entire number of brands furnish less than 60 cents' worth of plant food to the dollar.

(2) *Thirty-two per cent. of the total number of low priced goods contain plant food worth less than* 60 *cents for each dollar of cost,* while but *six per cent.* of the total number of medium grade and *none* of the high grade brands contain as little *relative* value as this.

(3) *Seventy-two per cent. of the total number of high class goods contain plant food worth more than* 70 *cents for each dollar of cost*, while but *twenty-nine* per cent. of the total number of medium grade and *sixteen* per cent. of the total number of low priced brands contained as much *relative* value as this.

Low grade brands cost relatively high prices because the expense of manufacture and sale are equally great as and proportionately greater than those on high class goods. The companies as a rule prefer to sell the better goods, but there is a wide-spread popular demand for low priced goods, a desire "to get a lot for the money." General and local fertilizer agents report difficulty in selling the higher grades, which must usually prove more satisfactory because of the greater economy of purchase and the greater likelihood that first-class materials are used in manufacture.

Agricultural Value of Fertilizers.—The comparisons shown are made from the *commercial* standpoint only and are designed simply to determine whether prices asked are reasonable. As has been already pointed out, one should not fail to consider the composition of the goods as of much more importance than the valuation.

Previous experience with similar goods, previous manuring and cropping of the land, the demands of the crop to be grown upon the soil, the character of the soil, as well as the fitness of the brand under consideration to soil, to crop and as supplementing home manurial supplies, should all be taken into account, and then, and not till then, the relation between selling price and "station valuation" should receive due weight.

AVERAGE COMPOSITION OF 94 BRANDS OF FERTILIZERS AS SOLD IN 1896 AND 1897.

Name of Ingredient.	1896.		1897.	
	Pounds in a hundred.	Valuation at 1897 prices.	Pounds in a hundred.	Valuation at 1897 prices.
Nitrogen	2.20	$6.16	2.12	$5.94
Soluble Phosphoric Acid	5 41	5.95	5.66	6.23
Reverted Phosphoric Acid	3.34	3.34	3.32	3.32
Insoluble Phosphoric Acid	2.27	0.91	2.15	0.86
Available Phosphoric Acid	8.75		8.98	
Total Phosphoric Acid	11.02		11.13	
Potash	3.41	3.07	3.31	2.98
Total valuation per ton		$19.43		$19.33

The comparison betrays but slight differences. The goods of the current year were a tenth lower in two and two tenths higher in one ingredient and "value" ten cents less. Owing to a sharp cut in the selling prices of mixed goods this year the average cost of plant food was less in 1897 than in 1896.

The following table shows the average of analyses, selling prices, valuations, percentages of increase of cost over valuation, and valuations of all at 1897 trade values of all brands analyzed each year since the Station has had charge of this class of work.

AVERAGE ANALYSES OF ALL BRANDS.

	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.
Nitrogen	2.38	2.58	2.75	2.80	2.55	2.41	2.52	2.42	2.41	2.21	2.22	2.22	2.12
Soluble Phosphoric Acid	6.35	6.15	5.48	6.74	6.68	5.99	6.74	6.47	6.44	5.42	5.84	5.36	5.34
Reverted Phosphoric Acid	1.93	1.92	3.23	2.80	2.97	2.97	2.86	2.60	2.84	2.97	2.56	3.44	3.68
Insoluble Phosphoric Acid	2 13	2.59	2.52	2.56	2.98	2.71	2.00	2.18	2.34	2.16	2.53	2.22	2.23
Available Phosphoric Acid	8.28	8.07	8.71	9.54	9.65	8 96	9.33	9.07	9.28	8.39	8.40	8.80	9.02
Total Phosphoric Acid	10 41	10.66	11.23	12.10	12.63	11.67	11.33	11.25	11.62	10.55	10.93	11.02	11.25
Potash	2.77	2.69	2.84	3.12	2.69	3.16	3.13	2.82	2.64	2.95	3.46	3.66	3.43
	$	$	$	$	$	$	$	$	$	$	$	$	$
Average selling price	37.90	37.02	36.75	35.13	35.11	34 39	33.14	32.47	32.32	31.47	30.90	30.90	29.19
Average valuation by each year's price	26.72	25.75	27.15	28.96	29.05	26.70	26.07	24.48	23.53	21.47	21.28	19.73	19.47
Per cent. increase of cost over valuation	42.	44.	35.	21.	21.	29.	27.	33.	37.	47.	45.	57.	50.
Valuation by 1897 prices	18.92	19.37	20.53	21.89	21.07	20.26	20.65	19.91	19.99	18.63	19.32	19.73	19.47

The lessened selling prices have resulted in making the most favorable showing in 1897 in the matter of cheap plant food of any year since the Station has had charge of the fertilizer control. Better goods were sold from 1887 to 1893 but cost from $3.00 to $7.50 more per ton. Plant food is cheaper today to the Vermont farmer than ever before. It is cheaper, however, not because manufacturers as a class are selling closer, but because of the lessened cost of crude stock or raw materials which enter into the manufacture of the goods. It follows therefore that those who practice home mixing can now as in years past in many cases save considerable amounts as compared with the direct purchase of factory mixed goods.

REPORT OF THE CHEMISTS.*

J. L. HILLS, B. O. WHITE AND C. H. JONES.

ANALYSES OF MISCELLANEOUS FERTILIZERS.

HOME MIXED FERTILIZERS, CRUDE STOCKS, ETC.

Station Number.	Material and Source.	Nitrogen.	Phosphoric Acid.					Potash.
			Soluble.	Reverted.	Insoluble.	Total.	Available.	
	HOME MIXTURES, ETC.							
5005	A. N. Bliss, Calais		0.29	3.47	15.54	19.30	3 76	5.94
5006	Rutland Fire Clay Co., Rutland; ("Plantene")	5.04	9.84	0.21	0.19	10.24	10.05	7.38
5011	C. A. Hutchinson, East Peacham; (for Potatoes)	3.93	2.42	1.86	1.89	6.17	4.28	10.62
5012	C. A. Hutchinson, East Peacham; (for Corn)	2.54	8.76	1.79	2.14	12.69	10.55	7.11
5018	E. A. Smith, Woodstock	3.22	8.91	2.06	1.12	12.09	10.97	4.53
5019	J. O. Sanford, Stamford	2.63	6.43	2.18	0.84	9.45	8.61	11.66
5022		2.91	0.00	6.66	8.31	14.97	6.66	0.05
5027	Bradley's XL (1896); W. S. Allen, Jacksonville	2.58	4.75	6.19	1.63	12.57	10.94	1.94
5028	Stockbridge Corn (1896); W. S. Allen, Jacksonville	3.59	7.30	3.99	1.12	12.41	11.29	4.25
	DISSOLVED BONE BLACK AND ACID PHOSPHATE.							
5009	D. B. B.; C. W. Webster, East Roxbury		11.29	4.40	2.36	18.05	15.69	
5407	D. B. B., (Bradley); H. L. Templeton, Montpelier		9.09	6.32	1.44	16.85	15.41	
5016	A. P., (Coe); Experiment Station		9.27	2.98	3.25	15.50	12.25	
5023	A. P., (Bowker); J. O. Sanford, Stamford				1.73	16.28	14.55	
5477	A. P., (W. & C. Co.); C. A. Hinsdill, No. Bennington		5.28	8.72	3.51	17.51	14.00	
5550	A. P., (Crocker); Experiment Station		12.95	3.82	1.99	18.76	16.77	
	NITRATE OF SODA AND TANKAGE.							
5021	Nit. Soda (Bowker); J. O. Sanford, Stamford		15.54					
5478	Nit. Soda (W. & C. Co.); C. A. Hinsdill, No. Bennington		15.74					
5409	Nit. Soda (Bradley); H. L. Templeton, Montpelier		15.43					
5551	Nit. Soda (Crocker); Experiment Station		15.35					
5010	Tankage; C. A. Hutchinson, East Peacham		7.23			10.78		
5040	Tankage } Robertson & Shiland, Burlington		5 29			16.16		
5041			4.52			15.60		
5042			3.31			13.11		

The home mixtures compared favorably in composition and mechanical condition with the better class of commercial fertilizers, and gave good field results. Parties wishing information regarding home mixing should apply for Bulletin 47.

*It is but fair to say that the work reported under this head represents but a very small fraction of the actual time of the chemists, which is largely taken up by the analyses of fertilizers, fodders, dairy products, etc. These, or results and conclusions based upon these, appear in other portions of the report, as well as in several of the bulletins.

It should also be stated that much of the work done in the laboratory during the past year was in connection with investigations which are as yet incomplete.

Station Number.	Material and Source.	Mechanical Analysis.			Nitrogen.	Total Phosphoric Acid.	Potash.
		Finer than 1-50 inch.	Finer than 1-25 inch.	Coarser than 1-25 inch.			
	GROUND BONE.						
5563	American Fertilizer Co.'s Ground Bone; M. J. Holt, South Woodstock	53	23	24	3.77	17.32	
5374	Lister's Increase Crescent Bone Dust; J. K. Curtis, St. Albans	44	26	30	2.81	15.06	
5375	Lister's Pure Raw Bone Meal; J. K. Curtis, St. Albans	55	27	18	2 87	24.06	
5260	Bradley's Fine Ground Bone; Brooks & Berry, Montpelier	66	19	15	2.45	21.12	
5417	Bowker's Market Bone; Norman Davis, Woodstock	86	9	4	2.62	20.58	
	MURIATE OF POTASH.						
5007	C. W. Webster. East Roxbury						51 26
5013	C. A. Hutchinson, East Peacham						51.94
5015	E. F. Coe Co.; Experiment Station						51.19
5020	Bowker; J. O. Sanford, Stamford						49.40
5476	W. & C. Co.; C. A. Hinsdill, North Bennington						50.17
5552	Crocker; Experiment Station						52.01
	SULPHATE OF POTASH, ETC.						
5014	E. F. Coe Co.; Experiment Station						50.80
5553	Crocker; Experiment Station						51.34
5408	Double Manure Salt. Bradley; H. L. Templeton, Montpelier.						25.00
5480	Sylvanite. Read; Gove & Taylor, Burlington						19.33

ANALYSES OF MUCK.

Station Number.	Received From.	ORIGINAL SUBSTANCE.				DRY MATTER.		
		Moisture.	Ash.	Organic and Volatile Matter.	Nitrogen.	Ash.	Organic and Volatile Matter.	Nitrogen.
5024	H. G. Thompson, Pawlet	61.66	6.90	31.44	1.19	17.99	82.01	3.10
5025	D. C. Wright, Westminster Station	36.03	9.26	54.71	1.35	14.50	85.50	2.11
5026	Louise C. Hunt, Fairfax	16.40	30.18	53.42	1.63	36.10	63.90	1.95
5032	N. C. Brodley, Warren	85.03	5.26	9.71	0.25	35.13	64.87	1.67
5035	E. K. Gray, Coventry	10.15	21.45	68.05	1.65	23.97	76.03	1.84
5036	C. de Nottbeck, Dorset	52.97	33.50	13.53	0.49	71.21	28.79	1.04
5038	C. de Nottbeck, Dorset	71.40	15.09	13.51	0.53	52.75	47.25	1.71
5044	H. B. Chapin, Middlesex	28.91	8.99	62.10	1.10	12.64	87.36	1.55
5512	M. S. Thomas, Isle LaMotte	70.47	3.75	25.78	0.92	12.70	87.30	3.13

Nine samples of muck varied from 1.04 to 3.13 per cent. of nitrogen. Nos. 5024 and 5512 are the best mucks thus far analyzed at this Station.

ANALYSES OF ASHES.

Station Number.	Source.	Received From.	Soluble Potash.	Insoluble Potash.	Total Potash.	Total Phosphoric Acid.	Insoluble Matter.
5002		W. V. Farr, Westminster Station	5.81	1.29	7.10	1.48	
5003		W. V. Farr, Westminster Station	5.10	1.00	6.10	1.28	
5004		F. J. LePierre, Burlington	8.01	0.89	8.90	1.54	
5030	Hard wood	N. C. Brodley, Warren	8.19	0.77	8.96	1.78	
5031	Soft wood	N. C. Brodley, Warren	4.23	1.88	6.11	2.98	
5034		LeG. B. Cannon, Burlington	5.05	0.23	5.28	1.57	
5039		C. G. Miller, Westminster	2.45	2.57	5.02	1.29	34.14
5043		W. V. Farr, Westminster	4.92	1.95	6.87	3.93	
5046		E. A. Smith, Woodstock	6.59	1.13	7.72	2.53	11.59
5510		W. P. White, East Ryegate	8.21	2.59	10.80	5.00	3.63
5511	Lime-Kiln	G. N. Shepardson, South Fairfax	3.48	0.37	3.85	1.98	2.93

Eleven samples of ashes have been analyzed during the past year. They varied from 2.45 to 8.21 per cent. soluble potash, and from 1.08 to 5.00 per cent. total phosphoric acid. The beneficial effects of ashes are quite as often due to the lime which they contain as to the potash. There are not such wide variations in this ingredient, however, as are found in the potash. It is safe to say that the goods represented by No. 5510 are worth much more than those represented by No. 5039. The price of this class of goods is seldom proportionate to quality. It is wise, therefore, to buy subject to analysis. Reputable dealers will usually allow a discount in case Station analysis shows deficiency.

5008. Harvester Fertilizer; manufactured by Harvester Fertilizer Co., Mechanicsville, N. Y.; from stock of F. Johnson, West Pawlet; contained no nitrogen, no phosphoric acid, 0.14 per cent. potash. About three-quarters of its weight consisted of ground lime-stone, it "valued" at thirteen cents a ton and it sold for nine dollars a ton. Sales were not in violation of the State law which exempts goods selling for less than ten dollars a ton from inspection and from the necessity of guaranteeing composition.

5017. Cremation Ashes. G. W. Allen, Essex Junction. These ashes were a mixture of wood ashes and bone, the result of burning the carcasses of about thirty-five tuberculous cattle. They contained total phosphoric acid, 21.24 per cent; potash, 2.72 per cent.

5045. Cotton Waste. C. C. Read, Burlington. This material, the waste from cotton mills, contained 0.87 per cent. nitrogen, 0.15 per cent. phosphoric acid, and 0.95 per cent. potash. It absorbed 55 per cent. of its weight of liquid in three minutes time.

ANALYSES OF DRINKING WATERS.

Thirty-eight samples of drinking water have been handled since the last report, the sources of the same being, 13 springs, 13 wells, 4 driven wells, 8 ponds, etc. The table indicates that 30 per cent. of the spring waters, 47 per cent. of the well waters and 50 per cent. of the pond, etc., waters were deemed impure and unsafe to use.

There have been 175 analyses of water samples made in the last four years. The ratio of impurity therein has been found to be: spring, 21 per cent.; well, 55 per cent.; pond, brook, etc., 41 per cent.

Station Number.	Class of Water.	Source of Sample.	PARTS PER MILLION.		GRAINS PER GALLON.			
			Free Ammonia.	Albuminoid Ammonia.	Chlorin.	Total Solids.	Fixed Solids.	Volatile Solids.
2130	SPRING WATER.	Dr. M. L. Chandler, Barre	0.025	0.08	0.3	14.9	12.3	2.6
2132		" " "	0.02	0.03	0.2	8.4	7.2	1.2
*2138		H. H. Gaines, East Enosburgh	0.03	0.16	0.2	5.1	3.3	1.7
*2142		Dr. M. L. Chandler, Barre	0.05	0.10	0.5	16.5	12.5	4.0
2143		" " "	0.03	0.04	0.3	14.8	8.4	6.4
2145		" " "	0.01	0.03	0.3	10.9	8.8	2.1
2149		J. N. Baxter, Rutland	0.04	0.06	0.3	12.1	7.0	5.1
2157		Mrs. L. K. Fuller, Brattleboro	0.01	0.01	0.3	8.4	7.4	1.0
2158		E. Goss, Olcutt	0.02	0.03	0.3	6.4	5.3	1.1
2161		G. O. Henry, Springfield	0.02	0.07	0.9	7.7	6.0	1.7
2163		B. E. Horton, North Clarendon	0.02	0.02	0.2	11.2	8.6	2.6
*2164		W. N. Gilfillan, South Ryegate	0.28	0.34	0.2	8.4	6.1	2.3
*2170		F. S. Collins, Burlington	0.04	0.08	2.9	10.9	9.8	1.1
*2128	POND, ETC. WATER.	A. W. Silsby, Newbury	0.12	0.70	0.2	5.2	3.7	1.5
2129		" " "	0.035	0.21	0.2	4.0	2.1	1.9
2131		Dr. M. L. Chandler, Barre	0.02	0.08	0.1	10.9	9.5	1.4
2133		" " "	0.02	0.06	0.2	12.3	10.9	1.4
*2141		" " "	0.08	0.17	0.5	12.7	7.0	5.7
†2144		" " "	0.045	0.12	0.4	9.7	7.4	2.3
2153		Geo. Aitken, Woodstock	0.015	0.105	0.2	7.0	4.2	2.8
*2171		Dr. A. M. Norton, Bristol	0.075	0.10	0.2	2.6	1.4	1.2
2123	WELL WATER.	C. L. Hodges, Randolph	0.035	0.10	1.9	19.8	15.4	4.4
2137		Geo. Aitken, Woodstock	0.01	0.14	0.8	11.1	5.6	5.5
*2139		J. C. Clark, Williston	0.03	0.16	2.0	37.8	31.8	6.0
2148		C. M. Sawyer, Randolph	0.04	0.05	0.6	16.5	9.1	7.4
2150		Geo. Aitken, Woodstock	0.02	0.05	0.8	8.8	5.3	3.5
2151		" " "	0.025	0.10	0.3	9.5	6.9	2.6
2152		" " "	0.02	0.10	0.5	5.6	3.2	2.5
*2155		C. D. Robinson, Waterbury	0.375	0.12	0.6	4.7	1.4	3.3
*2156		H. G. Beach, South Burlington	0.055	0.13	1.4	24.7	16.3	8.4
2159		L. U. Collier, Beebe Plain	0.01	0.07	0.6	22.8	17.9	4.9
*2162		J. W. Sheehan, Winooski	0.025	0.15	1.5	24.2	20.0	4.2
*2165		Franklin Heffion, Highgate	0.11	0.11	1.5	14.4	10.9	4.5
*2169		A. H. Stinson, Pleasant Valley	0.33	0.08	0.8	11.3	9.6	1.7
2122	DRIVEN WELL WATER.	Venetian Blind Co., Burlington	0.045	0.04	0.2	17.7	13.6	4.1
*2140		A. A. Byington, Charlotte	0.64	0.07	0.3	20.7	17.0	3.7
2146		F. M. Wedgwood, Essex Junction	0.02	0.04	0.4	5.0	2.3	2.7
2147		L. Richmond, Randolph	0.03	0.055	0.3	23.2	16.5	6.7

In sending samples of water to the station for analysis great care should be taken that the package and stopper be scrupulously clean and that it be rinsed out several times before filling, rinsing to be done with water from the same source as is sent. A new, clean, unused maple syrup can makes a

good package. A gallon is needed for analysis, which should be sent by express prepaid to Experiment Station, Burlington, Vt., with full statement regarding nature of water, reason for suspicion, surroundings, etc. The station cannot undertake the analysis of mineral waters.

The results of water analysis are best interpreted in connection with a survey of the surroundings of the supply. Chemical data which would pass a sample from one source would condemn another less favorably situated. Samples in the foregoing table marked * were considered impure ; those marked † were held to be somewhat suspicious.

MISCELLANEOUS ANALYSES.

Section 263 of the Vermont Statutes requires that the station "shall analyze feeding stuffs, milk, butter, oleomargarine....drinking water....provided that in (its) judgment such analyses will be for the public good." Although no funds are appropriated by the State to defray the expense incurred in complying with this law, the station has yearly done a large amount of gratuitous analytical work for the citizens of the State, the results of some of which are worthy of publication. Many hundred analyses, however, are of too little value to call for permanent record, and are not printed.

MATERIAL SUSPECTED OF BEING OLEOMARGARINE.

Station Number.	Received from		Remarks.
2111	S. Grout, East Dorset....	5.49 per cent. volatile acids.....	Butter.
2112	S. Grout, East Dorset....	5.36 " " " "	"
2167	L. F. Benton, Vergennes..	5.45 " " " "	"

MAPLE SAP, SYRUP AND SUGAR.

Station Number.	Name and Source of Material.	Polarization. (Direct.)	Polarization. (Indirect.)	Remarks.
2124	Syrup, Frank Kenfield, Morrisville.....	62.8	-17.4	Pure.
2125	Syrup, Frank Kenfield, Morrisville.....	62.6	-19.6	"
2126	Syrup, C. A. Larkin, Strafford.....	65.2	-22.2	"
2168	Sugar, E. E. Brigham, Morrisville.....	70.6		
2172	Sap, Alpha Messer, Rochester.....	3.37		
2175	Syrup, Brattleboro Jelly Co., Brattleboro.....	61.0	-24.0	"

The four syrup samples were suspected of adulteration but proved to be free from glucose. No. 2175 was heavily loaded with malate of lime (nitre). The sample of sap was thought possibly contaminated with zinc, it having

been allowed to sour in contact with zinc utensils. It contained 0.06 per cent. ash, 0.04 per cent. lime, 0.21 per cent. acidity (calculated as malic acid), 4.00 per cent. total solids and no appreciable quantities of zinc.

ADULTERATED HONEYS.

	I	II	III	IV	V
Specific Gravity	1.3202	1.3700	1.3867	1.4002	
Water	27.50	24.01	20.00	19.81	11.02
Ash	0.02	0.06	0.04	0.04	0.08
Acidity (as formic acid)	0.016	0.032	0.039	0.044	0.03
Sucrose (cane sugar)	63.48	20.35	21.03	22.08	16.97
Laevulose (honey sugar)	0.19	49.92	48.77	50.12	64.32
Polarization (before inversion)	+64.42	+ 11.00	+ 12.50	+ 13.80	+ 13.00
Polarization (after inversion)	—19.80	— 16.00	— 15.40	— 15.50	— 9.52

No. I was a sugar syrup, and Nos. II, III and IV were honeys obtained in experimental work involving feeding No. I to bees. No. V was sent to the station for analysis, and shows adulteration with cane sugar. It is impossible to say whether the adulteration was brought about by direct addition of sugar, or whether the material was fed to the bees.

ANALYSES OF MILL FEEDS.

Station Number.	Name and Source of Material.	Water.	Crude Ash.	Crude Protein.	Crude Fiber.	Nitrogen-free Extract.	Ether Extract.	Nitrogen.	Phosphoric Acid.	Potash.
4431	"Wheat by-product;" R. Amsden, Windsor	8.32	3.58	13.13	12.41	59.38	3.18	2.10	0.92	0.90
4432	Mixed Feed; H. A. Bixby, Burlington...	8.65	3.33	13.44	12.73	58.84	3.01	2.15	0.54	0.76
4434	Oat Feed; Speedwell Farms, Lyndonville	4.33	5.42	7.44	23.30	59	51	1.15		
4435	Oat Feed; Burl'ton Flouring Co., Winooski	6.22	5.50	8.86	19.70	59	72	1.42		
4438	Cleveland Flax Meal; R. P. Sellew, Boston	8.30	5.62	38.37	8.60	35.43	3.68	6.14	0.87	1.42
4439	Cream Gluten Meal; W. E. Dennis, Boston, Mass.	8.11	0.80	33.73	2.03	51.80	3.53	5.40	0.34	0.09
4440	Fancy Middlings; M. J. Holt, So. Woodstock	8.54	3.37	18.73	3.02	61.31	5.03	3.00		
4441	Standard Pillsbury Middlings; M. J. Holt, So. Woodstock.	7.90	5.27	17.07	7.65	56.30	5.81	2.73		
4442	Atlas Gluten Meal; Atlas Distilling Co., Peoria, Ill.	5.95	2.41	31.94	10.63	35.59	13.48	5.11	0.77	0.36
4443	Buckwheat Hulls; H. Hopkins, Sheldon.	8.86	2.99	15.44	20.73	47.68	4.30	2.47	0.58	0.88
4444	Middlings; L. B. & F. Howe, Jericho....	8.97	3.50	12.34	14.31	57.77	3.11	1.97	1.77	1.00

No. 4431 contained considerable amounts of a coarse woody material, reacting to the cellulose test. It is difficult to believe this to have been derived from wheat. No part of the wheat kernel from bran to flour contains as much crude fibre as does this sample The protein, moreover, is lower than that in any one of forty wheat products reported in the ninth report. There is strong presumption of adulteration.

No. 4434 and 4435 represent the "oat feeds" so called, now offered for sale. These "feeds" contain much less protein and much more crude fibre and ash than do oats and are probably mixtures of oats and oat hulls. Unless sold at very low prices the economy of their purchase may well be doubted.

PIG FEEDING.

By J. L. Hills.

Feeding experiments with pigs were conducted in 1896 in continuation of those made during previous years, being particularly designed to determine the feeding value of dairy by-products and farm-grown grains. They were planned to answer the following questions:

1. What are the relative feeding values of corn meal and whole corn? If the former is found to have greater value, is the gain equal to the cost of grinding? (Repetition of experiment reported in the Ninth Annual Report, pp. 57–65.)

2. What are the relative feeding values of skim milk and corn meal, and of whey and wheat bran?

3. Is skim milk most profitably fed in large or in small quantities?

The results of this series of trials seem to warrant the following interpretations:

1. Corn meal proved superior to shelled corn. It is doubtful, however, whether the gain was equal to the extra cost of grinding.

2. Whey in large quantities with bran proved a more economical feed than skim milk in large quantities with corn meal, but no more so than skim milk fed in small quantities with corn meal.

3. The economy of production was decidedly in favor of small rather than large quantities of skim milk.

4. Profits turned to losses as the average pig grew beyond 150 pounds, because of low prices for pork and illiberal feeding during middle life.

5. Subtracting the cost of grain from the total receipts, allowing manure to offset care, skim milk was found to be worth 18 cents (fed in small quantities), 12 cents (fed in large quantities), and 15 cents (average), while whey proved to be worth 11 cents per hundred.

6. The foods contained fertilizing ingredients worth 54 per cent. of their cost.

HISTORY.

Twelve pigs were used in this experiment, all of which were bought by Hon. G. S. Fassett, of Enosburgh.

They were fed alike for a few weeks on such amounts of skim milk as they would readily eat in order to get them into as nearly as might be uniform condition and to give them time to accustom themselves to their new quarters. The lot was somewhat less uniform than those used in previous years.

The pigs were divided into two lots of six each.

Lot A. Nos. 3, 4 and 6 received skim milk, corn meal and bran; Nos. 1, 2 and 5 received skim milk, shelled corn and bran.

Lot B. Nos. 7, 8 and 11 received skim milk, corn meal and bran; Nos. 9, 10 and 12 received whey, corn meal and bran.

Each pig in experiment I received six quarts of skim milk and twelve ounces of either corn meal or shelled corn daily throughout the feeding test, except that Nos. 2 and 6 received but three-quarters ration during the first ten days. All the pigs were started upon corn meal, and the three chosen for shelled corn feeding gradually accustomed to it after ten days had elapsed. Beginning June 24 (Nos. 1 and 3) and July 1 (Nos. 2, 4, 5 and 6) and ending Oct. 5 (No. 1), Oct. 17 (Nos. 3 and 4), Oct. 28 (No. 6), and Nov. 5 (Nos. 2 and 5), the pigs received daily the amounts of mixed feed (half wheat bran and half corn meal [or shelled corn]) indicated in the feeding table. Beginning Oct. 5, 17, 28 and Nov. 5, and coincident with the withdrawal of the mixed feed, increasingly heavy amounts of corn meal or shelled corn were fed until slaughter, as indicated in the feeding table.

Pigs 7, 8 and 11 in experiment II received daily an ounce of corn meal to a quart of skim milk for from forty to sixty days at the opening of the test, amounts increasing according to appetite, and from thence to the close received twelve quarts of skim milk and twenty-four ounces of corn meal.

Pigs 9, 10 and 12 in the same test received twelve ounces of bran daily until late in the test, and whey in increasing amounts until from thirty to forty days after the experimental feeding began, when the standard amount, twelve quarts daily, was fed, an amount which was continued throughout. Beginning July 20 (No. 12), July 30 (Nos. 7, 9, 10 and 11), and Aug. 22 (No. 8) half wheat bran and half corn meal were also fed in amounts indicated in the table, which was discontinued on Oct. 4 (Nos. 7 and 11), Oct. 26 (No. 12), Nov. 4 (No. 8), Nov. 15 (No. 9), Nov. 25 (No. 10), corn meal taking its place.

Owing to the low price of pork, as well as to a misunderstanding, the pigs were fed until heavier than any previous lot except that of 1895. The profits were therefore not large, as is clearly shown in the succeeding tables.

The following tables show:

I. Daily Rations of Pigs.

II. Food Eaten Each Period, and Total Food Eaten.

III. Gain in Live Weights by Periods.

IV. Live and Dressed Weights.

V. Total Food Eaten, Dry Matter Eaten to One Pound of Gain, and Financial Results.

I. DAILY RATIONS OF PIGS.

Period Number.	Dates.	All Pigs.		No. 3.		No. 4.		No. 6.		No. 1.		No. 2.		No. 5.	
		Skim Milk.	Corn Meal or Shelled Corn.	Bran and Corn Meal.	Corn Meal.	Bran and Corn Meal.	Corn Meal.	Bran and Corn Meal.	Corn Meal.	Bran and Shelled Corn.	Shelled Corn.	Bran and Shelled Corn.	Shelled Corn.	Bran and Shelled Corn.	Shelled Corn.
		qts.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
	June 24-30	6	12	6		—		—		6		—		—	
I.	July 1-10	6	12	11		10		10		12		6		6	
	" 11-21	6	12	27		27		22		27		21		24	
	" 22-29	6	12	40		40		36		43		24		24	
	July 30-Aug. 16	6	12	53		46		46		66		24		52	
II.	Aug. 17-31	6	12	68		60		60		72		32		58	
	Sept. 1-10	6	12	72		72		72		78		48		60	
III.	Sept. 11-Oct. 4	6	12	74		74		74		92		56		71	
	Oct. 5-16	6	12	84		84		84			84	66		84	
	Oct. 17-28	6	12		72		72	84			96	66		84	
	Oct. 29-Nov. 4	6	12		84		78	84			96	66		84	
IV.	Nov. 5-20	6	12		90		90		74		102		62		77
	" 21-30	6	12		99		96		78		108		72		84
	Dec. 1-17	6	12		102		96		78		108		78		90

Period Number.	Dates.	No. 7.		No. 8.		No. 11.			No. 9.		No. 10.		No. 12.	
		Skim Milk.	Corn Meal.	Skim Milk.	Corn Meal.	Skim Milk.	Corn Meal.		Whey.	Bran.	Whey.	Bran.	Whey.	Bran.
		qts.	oz.	qts.	oz.	qts.	oz.		qts.	oz.	qts.	oz.	qts.	oz.
	June 15-23	7	14	4½	9	9	9		6	12	4½	9	6	12
	" 24-30	7½	7½	6	6	9	9		6	12	6	12	6	12
I.	July 1-10	9	9	8	8	11	11		6	12	7	12	9	12
	" 11-19	10½	10½	10½	10½	12	12		9	12	9	12	12	12
	" 20-29	12	24	10½	10½	12	24		10½	12	10½	12	12	12*
	July 30-Aug. 3			10½	10½									
II.	Aug. 4-16			12	15									
	Aug. 17-21			12	24									

*Also 5 oz. bran and 5 oz. corn meal daily.

Period Number.	Dates.	Nos. 7-8-11.		No. 7.		No. 8.		No. 11.		Nos. 9-10-12.		No. 9.		No. 10.		No. 12.	
		Skim Milk.	Corn Meal.	Mixed Feed.	Corn Meal.	Mixed Feed.	Corn Meal.	Mixed Feed.	Corn Meal.	Whey.	Bran.	Mixed Feed.	Corn Meal.	Mixed Feed.	Corn Meal.	Mixed Feed.	Corn Meal.
		qts.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	qts.	oz.	oz.	oz.	oz.	oz.	oz.	oz.
II.	July 30-Aug. 5.....	12*	24*	16		—		16		12	12	10		6		21	
	Aug. 6-16.....	12*	24*	27		—		27		12	12	14		14		27	
	" 17-21.....	12*	24*	36		—		36		12	12	24		24		39	
	" 22-31.....	12	24	36		14		45		12	12	30		30		57	
	Sept. 1-10.....	12	24	36		27		58		12	12	36		36		63	
III.	Sept. 11-Oct. 4.....	12	24	45		30		54		12	12	39		39		68	
	Oct. 4-16.....	12	24		87	45			78	12	12	51		51		84	
	Oct. 17-26.....	12	24		96	54			84	12	12	54		54		84	
IV.	Oct. 27-Nov. 2.....	12	24		96	60			90	12	12	60		60			72
	Nov. 3-12.....	12	24		96		78		96	12	12	66		66			84
	" 12-21.....	12	24		96		84		102	12	12		84	80			96
	" 22-30.....	12	24		102		84		102	12	12		84		72		102
	Dec. 1-10.....	12	24		102		84		102	12	12		108		102		102
	" 11-17.....	12	24		102		84		102	12	12		102		102		102

II. FOOD EATEN EACH PERIOD AND TOTAL FOOD EATEN.

Period Number.		Skim Milk.	Whey.	Corn Meal.	Shelled Corn.	Bran.	Skim Milk.	Whey.	Corn Meal.	Shelled Corn.	Bran.	Skim Milk.	Whey.	Corn Meal.	Shelled Corn.	Bran.
	Pig Number.	3					4					6				
		qts.	qts.	lbs.	lbs.	lbs.	lbs.	qts.	lbs.	lbs.	lbs.	qts.	qts.	lbs.	lbs.	lbs.
I.		266	—	56	—	24	266	—	54	—	22	243	—	50	—	16
II.		258	—	118	—	87	258	—	106	—	75	258	—	106	—	79
III.		216	—	117	—	85	216	—	117	—	85	216	—	114	—	87
IV.		372	—	399	—	—	372	—	388	—	—	372	—	319	—	22
	Totals.....	1112		690		196	1112		665		182	1089		589		204
	Pig Number.	1					2					5				
I.		266	—	7	48	32	254	—	9	37	15	262	—	11	41	19
II.		258	—	—	127	95	258	—	—	76	43	258	—	—	107	74
III.		216	—	—	155	70	216	—	—	92	65	216	—	—	111	84
IV.		372	—	—	442	—	372	—	—	279	37	372	—	—	321	48
	Totals.....	1112		7	772	197	1100		9	484	160	1108		11	580	225
	Pig Number.	7					8					11				
I.		413	—	34	—		361	—	25	—		453	—	37	—	
II.		516	—	106	—	41	508	—	65	—	13	516	—	114	—	50
III.		432	—	167	—	34	432	—	93	—	39	432	—	135	—	39
IV.		744	—	383	—		744	—	286	—	31	744	—	373	—	
	Totals.....	2105		690		75	2045		469		83	2145		659		89

*Except No. 8.

Period Number.		Skim Milk.	Whey.	Corn Meal.	Shelled Corn.	Bran.	Skim Milk.	Whey.	Corn Meal.	Shelled Corn.	Bran.	Skim Milk.	Whey.	Corn Meal.	Shelled Corn.	Bran.
	Pig Number.	9					10					12				
I.		—	333		—	33	—	322		—	32	—	406		—	33
II.		—	516	33	—	65	—	516	32	—	64	—	516	59	—	91
III.		—	432	49	—	76	—	432	49	—	76	—	432	88	—	115
IV.		—	744	253	—	76	—	744	222	—	111	—	744	334	—	30
	Totals.....		2025	335		250		2014	303		283		2098	481		269

III. GAIN IN LIVE WEIGHT BY PERIODS.

Period Number.	Length of Period in Days.	Pig No. 3.			Pig. No. 4.			Pig No. 6.			Pig No. 1.			Pig No. 3.			Pig No. 5.		
		Beginning of Period.	End of Period.	Gain during Period.	Beginning of Period.	End of Period.	Gain during Period.	Beginning of Period.	End of Period.	Gain during Period.	Beginning of Period.	End of Period.	Gain during Period.	Beginning of Period.	End of Period.	Gain during Period.	Beginning of Period.	End of Period.	Gain during Period.
I.	45	47	104	57	42	92	50	33	83	50	55	110	55	32	79	47	37	83	46
II.	43	104	164	60	92	149	57	83	140	57	110	170	60	79	127	48	83	134	51
III.	36	164	209	45	149	200	51	140	183	43	170	217	47	127	176	49	134	177	43
IV.	62	209	326	117	200	321	121	183	276	93	217	334	117	176	268	92	177	264	87
		Pig. No. 7.			Pig No. 8.			Pig No. 11			Pig No. 9.			Pig No. 10.			Pig No. 12.		
I.	45	58	105	47	30	75	45	46	105	59	41	67	28	31	61	30	47	89	42
II.	43	105	166	61	75	130	55	105	168	63	67	118	51	61	113	52	89	147	58
III.	36	166	223	57	130	170	40	168	218	50	118	162	43	113	154	41	147	196	49
IV.	62	223	326	103	170	264	94	218	329	109	162	272	110	154	251	97	196	308	112

IV. LIVE AND DRESSED WEIGHTS.

Pig Number.....	3	4	6	1	2	5	7	8	11	9	10	12
Live weight.....	326	321	276	334	268	264	326	264	329	272	251	308
Dressed weight.....	276	277	238	281	221	214	273	222	283	230	205	258
Shrinkage in dressing.....	50	44	38	53	47	50	53	42	46	42	46	50
Percent. of shrinkage.....	15	14	14	16	17	19	16	16	14	15	18	16

V. TOTAL FOOD EATEN, DRY MATTER EATEN TO ONE POUND GAIN, AND FINANCIAL RESULTS.

Pig Number.	Skim Milk	Whey.	Corn Meal.	Shelled Corn.	Bran.	Total Dry Matter Eaten.	Gain in Live Weight.	Dry Matter Eaten for one lb. Gain in Live Weight.	Gain in Dressed Weight.	Dry Matter Eaten for one lb. Gain in Dressed Weight.	* Cost of Food Eaten for one lb. Increase in Dressed Weight.	Gain or Loss per pound of Dressed Weight.	Profit or Loss per Pig.
	qts.	qts.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	cts.	cts.	$
3	1112	—	690	—	196	987	279	3.54	236	4.18	4.03	+0.47	+1.11
4	1112	—	665	—	182	953	279	3.42	241	3.95	3.84	+0.66	+1.59
6	1089	—	589	—	204	903	243	3.72	210	4.30	4.19	+0.31	+0.65
1	1112	—	7	772	197	1064	279	3.81	235	4.53	4.32	+0.18	+0.42
2	1100	—	9	484	160	784	234	3.35	194	4.04	4.06	+0.44	+0.85
5	1108	—	11	580	225	927	227	4.08	184	5.04	4.87	−0.33	−0.55
7	2105	—	690	—	75	1084	268	4.05	222	4.89	5.38	−0.88	−1.95
8	2045	—	469	—	83	892	234	3.82	197	4.53	5.21	−0.71	−1.40
11	2145	—	659	—	89	1079	283	3.82	243	4.45	4.92	−0.42	−1.02
9	—	2025	335	—	250	803	231	3.48	195	4.12	3.94	+0.56	+1.09
10	—	2014	303	—	283	803	220	3.65	180	4.46	4.24	+0.26	+0.47
12	—	2098	481	—	269	954	261	3.66	218	4.38	4.10	+0.40	+0.87

* Bran, $12; corn meal, $14; skim milk, 15 cents; whey, 9 cents.

CORN MEAL AND SHELLED CORN.

The salient points of the tables on the preceding pages for the average pig of each set are as follows:

	Period.	Corn Meal.	Shelled Corn.
Gain in live weight per day in pounds	I.	1.16	1.10
	II.	1.35	1.23
	III.	1.29	1.29
	IV.	1.78	1.59
Average live weight Dec. 17 (pounds)		308	289
Average dressed weight Dec. 17 (pounds)		264	239
Per cent. shrinkage		14	17
Dry matter eaten per pound of gain in live weight (pounds)		3.55	3.75
Dry matter eaten per pound of gain in dressed weight (pounds)		4.14	4.54
Cost of food per pound increase in dressed weight (cents)		4.02	4.42
Total gain per pig, (dressed pork at 4½ cents)		$1.12	$0.24

The result throughout is strongly in favor of the ground corn. When the unground corn was fed the gain was slower, the pork produced was less, the shrinkage greater, the cost per pound greater, and the profit less.

The result of last year's test showed identical returns. Omitting one pig, however, which ate well but made poor gains, results were decidedly in favor of meal feeding.

The cost of hauling and grinding the corn may frequently prove an offset to the gain thus twice observed from feeding meal. It cost ten per cent. more to make a pound of dressed pork when shelled corn was fed than it did when corn meal was used. It would probably cost at least ten per cent. of the cost of the meal to pay for its carting and grinding.

SKIM MILK AND WHEY.

The salient points of the tables on the preceding pages for the average pig of each set are as follows:

	Period.	Skim Milk.	Whey.
Gain in live weight per day in pounds	I.	1.12	0.74
	II.	1.39	1.25
	III.	1.36	1.23
	IV.	1.65	1.72
Average live weight Dec. 17 (pounds)		306	277
Average dressed weight Dec. 17 (pounds)		259	231
Per cent. shrinkage		15	17
Dry matter eaten per pound of gain in live weight (pounds)		3.90	3.60
Dry matter eaten per pound of gain in dressed weight (pounds)		4.62	4.32
Cost of food per pound increase in dressed weight (cents).		5.17	4.09
Total gain (or loss) per pig (dressed pork at 4½ cents)		—$1.46	$0.81

The results of these tests are somewhat peculiar. The whey-fed pigs grew more slowly at first, but about as rapidly later on as did those fed skim milk. They made a smaller growth, shrank more in dressing, but made a pound of pork from less dry matter, and, rating skim milk at 15 cents and whey at 9 cents, made it more cheaply. This result is in part due to the fact, shown under the next heading, that the pigs fed large quantities of skim milk made their pork at a heavy loss, while those fed smaller quantities made it at a gain.

Apparently, large quantities of whey may be fed, if properly supplemented with bran instead of corn meal, and, at present prices for bran, prove a profitable ration. It is very doubtful whether whey and corn meal would prove successful, because of the comparative lack of protein in both feeds.

LARGE AND SMALL QUANTITIES OF SKIM MILK.

The salient points of the tables on the preceding pages for the average pigs thus fed are as follows:

	Period.	Large Amounts.	Small Amounts.
Gain in live weight per day in pounds.	I.	1.12	1.16
	II.	1.39	1.35
	III.	1.36	1.29
	IV.	1.65	1.78
Average live weight Dec. 17 (pounds)		306	308
Average dressed weight Dec. 17 (pounds)		259	264
Per cent. shrinkage		15	14

Dry matter eaten per pound of gain in live weight (pounds)	3.90	3.55
Dry matter eaten per pound of gain in dressed weight (pounds)	4.62	4.14
Cost of food per pound increase in dressed weight (cents)	5.17	4.02
Total gain (or loss) per pig (dressed pork at 4½ cents)—	$1.46	$1.12

The growth, rate of growth and shrinkage on dressing were much the same whether the pigs were fed much or little milk, but the economy of production was decidedly in favor of the smaller amount. Less food was needed to make a pound of pork, and the cost of the pork was less, the differences being sufficient to turn a slight profit into a considerable loss. In the eighth report a somewhat similar test showed that the ration containing the smaller amounts of skim milk was more satisfactory. The result was less marked than that obtained in 1896.

PROPER TIME TO MARKET PORK.

If there was ever a time when the constantly reiterated advice, based on previous tests at this station, to rapidly grow and promptly sell pork was pertinent, the past fall was that time. Profits are but small when pigs are grown heavier than 200 pounds live weight, even when pork sells well, but at 4½ and 5 cents, the prices of the past two years, the heavy pig is grown at a loss, and usually the heavier he grows the greater the loss.

The feeding in the present experiment shows an anomoly, however, a greater average cost for feeding during the middle of the feeding tests than was observed later. It appears that the pigs were not crowded hard enough during the late summer and early fall. Harder crowding would have probably resulted in better profits. It is noticeable that because of the low price of grain even the heavy pork was fed at only slight loss.

Period number.	Average weight at end of each period.	Average cost of food consumed for each pound increase in live weight	Average selling price per pound of live weight.	Average gain (or loss) per pound increase in live weight.	Total gain (or loss) during period.
	lbs.	cents.	cents.	cents.	
I. Beginning	42				
I. End	88	2.72	3.78	1.06	$5.85
II	146	3.53	3.78	0.25	1.74
III	190	4.68	3.78	—0.90	—4.75
IV	295	3.84	3.78	—0.06	—0.76

The cost of the daily feeding of the average pig increased rapidly as the animal grew in age and size as is shown by the average figures for each period; I, 2.78 cents; II, 4.76 cents; III, 5.73 cents; IV, 6.37 cents.

FINANCIAL SUMMARY.

The financial returns of the experiments made during 1896 were unsatisfactory, owing to reasons already stated.

The twelve pigs gained 3,040 pounds in live weight, which sold for $115.29. The average cost of corn meal and bran during the tests were $14.00 and $12.00 respectively. Reckoning skim milk at 15 cents and whey at 9 cents per hundred, the food eaten cost $112.74, leaving as profit but $2.55.

If the original cost of the pigs is taken into account, a method of calculation which does not strictly apply except where yearly purchase is made, the calculation would be as follows:

2,978 pounds of dressed pork at 4½ cents		$134.01
Cost of pigs	$ 24.00	
Food for pigs	116.11	
		140.11
Loss		$ 6.10

VALUES OF SKIM MILK AND WHEY.

The main purpose for which pigs are kept in dairy sections is as a profitable means for the disposal of the by-products. In years past the comparative feeding values of skim milk and buttermilk have been determined by experiments at this and other stations, but no tests of the value of whey in pig feeding seems to have been made in America except at the Wisconsin Station.* This by-product obviously does not have the food value of skim and buttermilks since the casein has been largely removed in the cheese. The albumens, together with some casein and fat, the milk sugar and the ash, however, give the whey a definite food value which is not to be despised.

The fairest way to get at the relative food values is to subtract the cost of the grain from the total receipts, allowing the manure to offset the care, and to call the remainder the equivalent of the values of the by-products. It will be remembered that the heavy feeding of skim milk was not profitable, and it seems best to separate the results accordingly.

1,543 pounds increase in live weight sold for	$58.47
1,971 pounds of corn meal, 1,836 pounds of shelled corn, and 1,164 pounds of bran cost	33.63
6,633 quarts of skim milk were worth	$24.84

or eighteen cents per 100 pounds.

*Rpt. Wis. Exp. Sta., 8 (1891), pp. 38-48; Bul. do., 27.

785 pounds increase in live weight sold for.....$30.03
1,818 pounds of corn meal, and 247 pounds of bran cost..... 14.21

6,295 quarts of skim milk were worth.....$15.82
or twelve cents per 100 pounds.
712 pounds increase in live weight sold for.....$26.79
1,119 pounds of corn meal, and 802 pounds of bran cost..... 12.65

6,137 quarts of whey were worth.....$14.14
or eleven cents per 100 pounds.

Fifteen cents per hundred was the average of all the results on skim milk. It should be remembered, however, that when fed in moderate quantities (six quarts per day), returns were better than when freely fed (twelve quarts per day); also that the former method proved profitable even at the unprecedented low price of 4½ cents for dressed pork, while the latter method of feeding was unprofitable. Had grain rated at the prices of former years, all the pork would have been made at a loss.

Up to last year twenty-five cents and upwards have been obtained for skim milk as a result of this method of figuring, but the low prices and prolonged feeding of the past two years have lessened the money return and the value obtained from its use.

It is doubtful whether eleven cents per hundred is not too high a figure at which to rate the feeding value of whey. Bran replaced corn meal in the whey ration, thus supplying in a measure the missing protein. The lower price of the grain having the greater food value which was thus largely fed, serves unduly to inflate the money worth of the whey as well as to better the food value of the ration. On the other hand had the pigs been slaughtered earlier this figure would have been higher yet.

FERTILIZING VALUE OF FEEDS.

The materials fed these pigs were rich in plant food, and the value of the manure is an ample offset against the labor.

Skim milk and whey are worth 10 and 4 cents per hundred, corn meal $5.25 and bran $9.60 per ton as fertilizers (1896 and 1897 trade values). The total fertilizing value of the food eaten by the twelve pigs was $60.63, and it cost $112.74. Its fertilizing value was therefore 54 per cent. of its market price as food, a large proportion of which may be saved by proper handling.

REPORT OF THE BOTANIST.

L. R. JONES.

The subjects claiming principal attention during the past year have been as heretofore plant diseases and their remedies. This year marks the satisfactory completion of the laboratory work upon the potato blights. Diseases of the apple as well as maladies of several less important crops have also received further investigation. And, finally, a large amount of time and energy have been devoted to the study of the orange hawkweed or "paint brush," particularly by Mr. W. A. Orton, of the class of 1897 of the agricultural department of the University of Vermont, largely in connection with the preparation of his thesis for graduation. The practical results of this investigation were made available in Bulletin 56, which publication has aroused considerable popular interest and elicited much correspondence, not only regarding the hawkweed but also other weed plants, their present distribution, channels of introduction, methods of eradication, etc. Field and laboratory work are now in progress looking towards an increase in knowledge upon these points.

Valuable assistance was rendered in the laboratory studies of the summer of 1896 by Mr. A. J. Grout and in the field by Mr. Orton. A large share of the results based upon their work was published in the ninth report, which proportionately abbreviates the present issue, which really represents the work of but little more than half a year.

The results of the more important investigations made in the botanical department since the last report are discussed in the following order :

I. Potato Diseases and Remedies.
 1. Potato Diseases as they occurred in 1896.
 2. Studies upon the Fungi associated with Early Blight.
 3. Tests of various forms of Bordeaux Mixtures.
 4. The Effect of Disinfectants upon the Growth of Potatoes.

II. Orchard Diseases and Remedies.
 1. Results from Spraying with Bordeaux Mixture.
 2. Apple Scald.

III. Observations upon Oat Smut.

IV. The Onion Mildew.
 1. Laboratory Studies upon the Fungus.
 2. Field Experiments with Fungicides.

V. The Orange Hawkweed or "Paint Brush."

I. POTATO DISEASES AND REMEDIES.

1. POTATO DISEASES AS THEY OCCURRED IN 1896.

The warm rains early in August gave climatic conditions which led to the belief that the late blight fungus would soon begin a rapid and destructive development. These favoring conditions changed, however, before the disease got started, and did not again occur. As a result there was no outbreak of this disease at Burlington, and very little of the dry rot has been found in the potato bins during the winter. The various other blights of the potato occurred much as in 1895.*

The observations and conclusions of past years were fully sustained as to the relatively large destruction of potato foliage by arsenical poisoning (from improper use of Paris green), and by the trouble which we have termed "tip-burn." Reports from other parts of the country strengthen the belief that this latter trouble is very general, and everywhere confused with the true early blight.

2. STUDIES UPON THE FUNGI ASSOCIATED WITH EARLY BLIGHT.

The essential results of the laboratory studies of 1895 and of the summer of 1896 were included in the report for 1895. Two species of fungi commonly found on blighting potato leaves are there figured and described. One, heretofore known as *Macrosporium Solani* E. & M., has been shown to be the cause of the early blight. The other closely resembles this first, but has proved to be a saprophyte, and, therefore, nearly or quite harmless. The intimate association of the two and their close resemblance has led to much confusion regarding them, as is explained in the last report. As noted also therein the parasitic species known heretofore as a *Macrosporium* was found in some cases to produce its spores in chains, which necessitates that it be called an *Alternaria*. Since Dr. Paul Sorauer has already described this species as *Alternaria Solani*, Sorauer, it should hereafter be so designated In order to define clearly the species, we insert the following technical description:

ALTERNARIA SOLANI (E. & M.) Sorauer, Zeitschrift fur Pflanzen Krankheiten, **6**: 6. 1896.

Macrosporium Solani E & M. American Naturalist, **16**: 1003. 1882.

Macrosporium Solani Cooke. Grevillia, **12**: 32. 1883.

Conidiophores dark brown, erect or ascending; somewhat curved, septate, 50–90 by 8–9 microns; conidia obclavate, brown, 145–370 by 16–18 microns, terminating in a very long hyaline septate beak, equalling fully one-half the length of the spore (often exceeding this), body of spore with 5–10 transverse septa, longitudinal septa few or lacking.

Common and destructive as a parasite on leaves of the potato (*Solanum tuberosum*), also on tomato (*Lycopersicum esculentum*), and Jamestown weed (*Datura Stramonium*).

*Rpt. Vt. Exp. Sta., 9 (1895), p. 78.

The following is, so far as we know, a complete bibliography of Alternaria Solani (E. & M.) Sorauer:

Ellis, J. B. Am. Nat. **16**: 1003. 1882.
Botanical description of the fungus as occuring on dying leaves of potato at Newfield, N. J.

Cooke, M. C. Grevillia. **12**: 32. S 1883.
Describes this fungus on Datura Stramonium as Macrosporium Solani Cooke.

Galloway, B. T. Gard. and Fld. Je 1891. (Adelaide, Australia.)
Records injury to potato plants by this fungus observed in U. S. in 1890 and in 1891 and successful use of bordeaux mixture as a preventive.

Humphrey, J. E. A New Potato Disease.
Rpt. Mass. State Exp. Sta. **9**: 226. 1891.
Records destructive potato leaf-blight associated with and apparently caused by this fungus.

Chester, F. D. A Leaf Blight of the Potato.
Rpt. Del. Exp. Sta. **4**: 58-60. *f.4*-7. 1891.
Describes the fungus and states that it occurs on potato causing serious leaf-blight, also on tomato. Records results of inoculation experiments with the fungus on tomato leaves.

———A Leaf Blight of the Potato.
Bul. Del. Exp. Sta. **15**: 13-14. Ja 1892.
Practically a reprint of the preceding.

———Diseases of the Round Potato and their Treatment.
Rpt. Del. Exp. Sta. **5**: 67-70. 1892.
Records destructive occurrence of this fungus and results of experiments in use of bordeaux mixture as a preventive.

Fletcher, J. Potato Blight.
Rpt. Canada Exp. Farms. **6**: 163-164. 1892.
Records destructive occurrence of this fungus upon potatoes at Ottawa, 1892, and usefulness of bordeaux mixture as remedy.

Halsted, B. D. Rpt. N. J. Exp. Sta. **13**: 326. 1892.
Notes occurrence of this fungus as a partial parasite on tomato fruits.

Jones, L. R. The New Potato Disease or Early Blight.
Rpt. Vt. Exp. Sta. **6**: 66-70. *pl. 4*. 1892.
Description of the "early blight" apparently due to this fungus.

Sturgis, W. C. Diseases of the Potato.
Rpt. Conn. Bd. Agr. **27**: 228-230. 1893.
Popular account of early blight, recommending the use of bordeaux mixture.

Pammel, L. H. Experiments to prevent certain Leaf-spot Diseases of the Potato. Bul. Ia. Exp. Sta. 20: 719-720. F 1893.
Notes occurrence of blight and the association of Macrosporium with it; also gives results of field trial with bordeaux mixture as preventive.

Galloway, B. T. The Macrosporium Potato Disease.
Agr. Sci. 7: 370-382. Ag 1893.
Detailed review of observations to date upon the fungus, with account of laboratory studies, artificial cultures, inoculations and results of field experiments with various fungicides and preventives.

Jones, L. R. Potato Blights and their Remedies.
Bul. Vt. Exp. Sta. 36: 1-4. *f. 3-5.* A 1893.
Popular description of early blight as distinguished from the late blight (Phytophthora) and recommendations regarding use of bordeaux mixture.

Rolfs, P. H. Bul. Fla. Exp. Sta. 21: 36-37. O 1893.
States that fungus occurs destructively on leaves, stem and fruit of tomato, and that tests show bordeaux mixture to be efficient remedy.

Goff, E. S. Rpt. Wis. Exp. Sta. **10**: 245-246. 1893.
Describes a potato blight attributed to the attacks of this fungus and gives results of experiments with bordeaux mixture as preventive. (For more popular account of the same work see Bul. Wis. Farm Inst. 7: 76-77. *f. 1-2.* 1893.)

Jones, L. R. Rpt. Vt. Exp. Sta. 7: 42-43 and 46. 1893.
Notes on occurrence of early blight of potatoes and discussion of the causal relation of the Macrosporium to it. Experiments showing the value of bordeaux mixture as a preventive.
———Bul. Vt. Exp. Sta. 40: 20-21. D 1893.
Popular discussion of results given in last reference.

Lamson, H. H. Rpt. N. H. Exp. Sta. **5**: 166-168. 1893.
Popular account of the blight of potatoes associated with this fungus with report on favorable results from experimental use of bordeaux mixture as a preventive.

Sturgis, W. C. Rpt. Conn. (New Haven) Exp. Sta. **17**: 74 and 101. 1893.
Mentions occurrence of the fungus; considers it an open question whether it is the primary cause of the disease.

Lamson, H. H. Early Blight.
Bul. N. H. Exp. Sta. 22: 6. My 1894.
Discusses occurrence of disease in N. H. and probable value of bordeaux mixture as preventive.

Rane, F. W. The Leaf-blight of the Potato.
Bul. W. Va. Exp. Sta. 38: 39-40. *f. 1.* N 1894.
Notes the occurrence of the fungus in W. Va. causing destructive blight; discusses susceptibility of varieties and use of bordeaux mixture.

Galloway, B. T. The Macrosporium Potato Disease.
Farmers' Bul. U. S. Dept. Agr. 15: 4-6. *f. 2.* 1894.
Popular illustrated description of the Macrosporium potato disease with directions for use of bordeaux mixture as preventive.

Jour. (British) Bd. Agr. 1: 199-217. 1894.
Descriptive notes on potato blights and bordeaux mixture.

Halstead, B. D. Rpt. N. J. Exp. Sta. **15**: 290, 354, 359, 360. *f. 42.* 1894.
Notes spotting of tomato leaves by this fungus as the worst of tomato blights, and also states that this is the most serious fungous enemy of the potato.

Jones, L. R. Rpt. Vt. Exp. Sta. 8: 95. 1894.
Notes upon occurrence of this fungus at Burlington, 1894.

Sturgis, W. C. Notes on "Early Blight" of Potatoes.
Rpt. Conn. Exp. Sta. 18: 127-135. 1894.
Critical discussion of investigations to date, with conclusion that the fungus is either a partial parasite or a wound parasite.

Beach, S. A. Bul. N. Y. Exp. Sta. 86: 100 and 102. F 1895.
Notes occurrence of this fungus on potato and tomato causing blights.

Fletcher, J. Potato Blights.
Bul. Canada Exp. Farms. 23: 24. *f. 5.* Ap 1895.
Notes occurrence of fungus in Canada causing much loss.

Lamson, H. H. Bul. N. H. Exp. Sta. 27: 8-10. Ap 1895.
Discusses nature of disease and means of recognition, and gives results of use of bordeaux mixture as a preventive.

Tracy, S. M. and **Earle, F. S.** Bul. Miss. Exp. Sta. 34: 121. My 1895.
Note on occurrence of the fungus in Miss. on Datura Stramonium.

Grosjean. Le Macrosporium de la Pomme de Terre.
Bul. Minister de L'Agric. *f. 1-2.* My 1885. (Paris.)
Popular description, with figures based on various American publications.

Kirk, T. W. Some Potato Diseases and How to Prevent Them.
Leaflet New Zealand Dept. Agr. 25: *f. 1.* Je 1895.
Figures and describes the Macrosporium disease of the potato as the most serious fungous malady of this plant in Australia and advises the use of bordeaux mixture.

Halsted, B. D. Rpt. N. J. Exp. Sta. **16**: 326, 339 and 344. 1895.
In experiments with bordeaux mixture, copper sulphate solution and potassium sulphide solution for controlling this fungus, the first gave fair results, the two latter were of no value.

Jones, L. R. Bul. Vt. Exp. Sta. 49: 91-94. *f. 1-2.* D 1895.
Popular illustrated description of the early blight contrasting the injuries from the fungus with those caused by arsenical poison and "tip burn."

———Rpt. Vt. Exp. Sta. **9**: 78-86. *pl. 1-3. f. 12.* 1895.
Detailed account of laboratory and field investigations leading to the conclusion that the fungus is a true parasite and the primary cause of the early blight, also that it is an Alternaria rather than a Macrosporium. (Issued Aug. 1896.)

Weed, C. M. Fungi and Fungicides. 164-165. 1895.
Brief popular description of potato blight caused by this fungus; bordeaux mixture recommended.

Sorauer, Paul. Auftreten einer dem amerikanischen "Early Blight" entsprechenden Krankheit an den deutschen Kartoffeln. Zeit. Pfl. Krankh. **6**: 1-9. *pl. 1.* 1896.
Records occurrence of destructive blight of potatoes in Hungary due to this fungus; results of inoculation experiments and of laboratory studies lead to belief that it is an Alternaria.

Lodeman, E. G. Diseases of the Potato.
Bul. Cornell Exp. Sta. 113: 254-261. *pl. 1.* F 1896.
Notes destructive occurrence of early blight in N. Y. and discusses causes, concluding that the fungus is not a true parasite but attacks only weakened or injured foliage.

Stewart, F. C. Potato diseases on Long Island in the Season of 1895.
Bul. N. Y. Exp. Sta. **101**: 76-77. F 1896.
Notes destructive occurrence of early blight due to this fungus, and gain from use of bordeaux mixture.

Garman, H. Potato Blight.
Bul. Ky. Exp. Sta. **61**: 18. Mr 1896.
Spot disease of potatoes in Kentucky, possibly attributable to this fungus; bordeaux mixture recommended.

Jones, L. R. Potato Blights.
Gard. and For. **9**: 188-189. My 1896.
A discussion of the various causes leading to the premature dying of potato leaves.

Selby, A. D. Bul. Ohio Exp. Sta. 73: 241. D 1896.
Notes occurrence of the fungus in Ohio on tomato, causing leaf-spot.

Halsted, B. D. Rpt. N. J. Exp. Sta. **17**: 355. 1896,
Records successful use of bordeaux mixture on potatoes in 1896 for controlling leaf blight.

Lodeman, E. G. The Spraying of Plants. 345-347. *f. 79.* 1896.
Describes and figures early blight of potato due to this fungus; bordeaux mixture recommended.

Stewart, F. C. Spraying Potatoes in Long Island in the Season of 1896. Bul. N. Y. Exp. Sta. 123. Ap 1897.
Discusses amount of injury by this fungus and comparative values of various fungicides in checking it.

Sajo, Karl. Beobactungen uber die Durrflecken Krankheiten der Kartoffeln in Jahre 1896. Zeit. Pfl. Krankh. **7**: 4-9. 1897.
Notes upon the early blight of the potato as it occurred in Hungary in 1896.

Jones, L. R. and Grout, A. J. Notes on two species of Alternaria. Bul. Torr. Bot. Club. **24**: 254-258. *f.1-2. pl. 308.* My 1897.
Summary of work upon Alternarias at Vt. Exp. Sta. in 1896 with botanical description of the fungus.

Lamson, H. H. Bul. N. H. Exp. Sta. 45: 50. My 1897.
Gives results of treatment with bordeaux mixture.

In connection with investigations upon *Alternaria Solani* Mr. Grout continued the studies during the summer of 1896 upon the puzzling species associated with it upon potato leaves described and figured in our last report.*

This should now be known as *Alternaria fasciculata* for reasons given below.† "All attempts at inoculation of living potato leaves with this fungus failed to produce infection even under the most favorable greenhouse conditions. During the summer, studies of the fungus diseases of the onion were undertaken and on some of the dead onion leaves a fungus was found so closely resembling this *Alternaria fasciculata* as to be indistinguishable from it. Spores of *Alternaria fasciculata* from a pure culture from potato leaves were sown on dead onion leaves still attached to a living plant. A rank growth of the mycelium bearing the characteristic Alternaria spores soon appeared on the inoculated spots but none elsewhere, showing the undiscriminating nature of the plant, for a fungus that will grow on dead leaves of onions and of potatoes can scarcely be restricted to any group or groups of plants.

*Rpt. Vt. Exp. Sta., 9 (1895), pp. 84-85.

†Extracted from article by L. R. Jones and A. J. Grout in Bul. Torr. Bot. Club, 24 (1897), pp. 254-258.

When later in the summer the study of tomato rots was taken up, it was found that the fungus which appears in black patches on the decaying tips of the fruit was an *Alternaria* not distinguishable from the one on the onion and the potato. It was further shown that this fungus did not cause the rot,* for green tomatoes inoculated with spores from a pure culture from the tomato remained for ten days in a moist chamber until they ripened without showing signs of rot, and cultures made from tomatoes just beginning to rot would not yield the Alternaria.

Alternaria fasciculata was found on the dead leaves of beans, cabbage, *Lathyrus palustris*, on hulls of oats and dead stems of buckwheat; also on dead leaves of corn where it equals *Macrosporium Maydis* E. & E., on paste board, equalling *M. chartarum* Pk., on ripe pods of radish, equalling *M. fasciculatum* E. & E. Doubtless further investigations will identify many other Macrosporium species with this omnipresent saprophyte, and doubtless also an older name than the one given above will be applied to it."

To aid in clearing up this matter the following description and synonymy are added, also reprinted from the same article.

ALTERNARIA FASCICULATA (C. & E.)

Macrosporium chartarum Pk. Rpt. N. Y. Mus., **25**: 93. 1873.
(Not Preuss., 1848.)
Macrosporium fasciculatum C. & E. Grevillia, **6**: 6. *Pl. 96.* 1877.
Macrosporium Maydis C. & E. l, c. 87.
Macrosporium Tomato Cooke, Grevillia, **12**: 32. 1883-4.
Alternaria Solani, Sorauer (in part) Zeit. Pfl. Krankh, **6**: 1-9. *Pl. 1*, 1896.

Conidiophores brown, erect or ascending, irregularly curved, solitary or caespitose, septate, diameter uniform, 40-130 microns long by 3 wide; conidia dark brown, oblong-ovate, minutely apiculate, 9-14 microns wide by 35-90 long, endochrome transversely 2-7 septate, with usually several longitudinal septa, the apical cell short or elongated into a straight somewhat hyaline beak, fruiting freely in pure cultures on nutrient media. On dead and decaying vegetable matter of many kinds.

The spores vary a great deal according to the stage of their development.

Careful comparisons were made with Ellis & Everhardt's Fungi Columbiana No. 399, *Macrosporium fasciculatum*, also with No. 396, *M. chartarum*.† There was no opportunity of comparing with *Alternaria chartarum* Preuss. which may prove to be the same thing.

*It is worthy of note in this connection that Selby, (Bul. Ohio Exp. Sta., 73 (1896), p. 241), speaking of the rot of tomatoes usually attributed to this fungus, expresses the opinion as the result of his observations and experiments that this "point rot" is associated with insufficient moisture in the soil, and that "lack of moisture is a condition, if not a cause of this form of green rot." This would place the disease in the same category as the tip burn of potato leaves which has the same fungus associated saprophytically with it.

†Specimens growing on old pasteboard were submitted to Mr. C. H. Peck who replied as follows: "The specimen you send is evidently the same as that which I called *Macrosporium chartarum*. Your investigations appear to me to show clearly enough that these genera [Macrosporium and Alternaria] are one and cannot both be kept alive."

3. TESTS OF VARIOUS FORMS OF BORDEAUX MIXTURE.

Twenty-four rows of potatoes were reserved for experimental spraying in continuation of the work of former years. In order to justify closer comparisons every other row was left unsprayed as a check. Upon the remainder the following fungicides were tested:

1. *Standard Bordeaux Mixture:** Copper sulphate 1½ lbs., lime 1 lb., water 10 gals.

2. Bordeaux mixture with one-half the usual amount of lime, i. e. copper sulphate 1½ lbs., lime ½ lb., water 10 gals. This amount of lime is sufficient to neutralize the sulphate, the standard mixture having a large excess of lime.†

3. Bordeaux powder, consisting of the precipitate of standard bordeaux mixture dried and ground into a very fine powder. This was applied dry with a "powder gun."

The averages of the entire series are as follows in pounds per row:

	Large tubers.	Small tubers.
Standard bordeaux mixture	108.6	7.7
Half-lime bordeaux mixture	110.9	8.0
Bordeaux powder	81.2	7.8
Check (no fungicide)	85.8	9.2

The gain from spraying with bordeaux mixture was about 24 lbs. per row, or 28 per cent. It should be remembered that this gain occurred in spite of the fact that there was no late blight (Phytophthora) or rot. It emphasizes again the truth that it *will repay every potato grower to spray his entire field every year*, whether the late blight is feared or not.

The main questions in the experiment are, however, as to the relative values of the two forms of bordeaux mixture and of the bordeaux powder. There can be no doubt as to the last. The average yield of the rows where the powder was used was less than that from the checks. Examination of the yields in detail justifies the belief that this apparent loss may be due to unavoidable variations resulting from inequalities in soil, etc. There is no doubt, however, that this powder is practically worthless as a fungicide for use on potatoes. This is in full accord with our results of former years,‡ and with similar tests at other stations.§

The other question raised in this experiment is as to the relative values of the standard and of the half-lime mixtures. The average is slightly in favor of the half-lime mixture. A closer examination of results shows that in two of the four cases where the two fungicides may be fairly compared, the

*Made by diluting both the sulphate solution and the lime-milk with one-half of the total water used, and pouring the sulphate solution into the lime while stirring vigorously. This gives the best mixture known. (See Ninth Report, p. 89).

†Rpt. Vt. Exp. Sta., 9 (1895), pp. 92 and 97.

‡Rpt. Vt. Exp. Sta., 9 (1895), p. 98.

§Bul. N. Y. Exp. Sta., 123 (1897), pp. 253-254.

standard mixtures gave larger returns than did the adjacent half-lime mixture, while in the other two cases the half-lime mixture gave the better returns. The results from the two are therefore so nearly identical that it may safely be concluded that there is practically no choice between them.

It becomes then merely a matter of convenience as to which mixture shall be used. The half-lime mixture is somewhat more desirable in that the smaller amount of lime present decreases the trouble from clogging of nozzles by the mixture. On the other hand one is running near the danger line in using so little lime. If the lime should be very poor or impure, the smaller amount might not neutralize the sulphate, and the mixture would be quite certain to injure the plants. It is therefore safer, and on the whole better as a rule, to use the standard mixture unless one is sure of the good quality of the lime employed, or is prepared to test the mixture in some way so as to determine that all the copper sulphate is neutralized.

The half-lime mixture does not color the sprayed plants so deep a blue, and for this reason there are cases when it is much to be preferred to the standard mixture. This is especially true where ornamental plants are to be sprayed, or where there is danger of staining fruit.

4. THE EFFECT OF DISINFECTANTS UPON THE GROWTH OF SEED POTATOES.

Our experience of the past few years has led to the belief that the disinfection of seed potatoes with corrosive sublimate solution, as practiced for the prevention of the scab, may retard the "germination" or early growth of the potato plants.*

In most cases injury has not been sufficient to be worthy of account, the plants from the disinfected seed quickly overtaking those from the untreated seed. In some cases, however, the results have been more disastrous. This has been especially true when the conditions of soil or weather were unfavorable to the young plants or when the seed tubers were of low vitality, more especially when the tubers had sprouted considerably before planting. This effect was very apparent in 1896 when a period of very dry weather followed planting. We quote from our ninth report:

"Disinfection of the seed [by corrosive sublimate] performed just prior to planting in all cases retarded the germination and apparently weakened the young plants. It is probable that this is due to the injurious action of the poison on the sprouts and that the more advanced sprouts are more liable to injury than those in a more dormant condition. If this is the correct explanation it follows that the disinfection should be performed earlier, either the previous fall or during the winter instead of being delayed until just before planting time as is the usual practice."

A series of experiments to test the correctness of these conclusions was carried out during the winter and spring of 1896. These experiments were repeated in 1897 and similar tests were made of the formalin solution recom-

*Rpt. Vt. Exp. Sta., 9 (1895), p. 102.

mended by Arthur* as a substitute for the corrosive sublimate. In all cases tubers of uniform weight and appearance were selected early in the winter and laid aside for this work. In the experiments of 1896 four varieties were used, in 1897 only two varieties.

The plan both seasons was to disinfect in the same manner at successive dates and observe the effect upon the early growth. The planting was done May 23 in 1896 and May 10 in 1897.

The complete records of germinations would make a confusing series of tables, and therefore we present only the averages as follows:

SEASON OF 1896. Disinfection by soaking one and one-half hours in 1-1000 corrosive sublimate solution (2¼ ounces in 15 gallons of water.)

Number of days after planting.	PER CENT. OF TOTAL NUMBER OF PLANTS ABOVE GROUND AT FROM NINETEEN TO THIRTY DAYS FROM PLANTING.			
	Untreated.	Disinfected on day of planting.	Disinfected 46 days before planting	Disinfected 96 days before planting.
19	6	1	6	4
20	20	5	17	22
21	31	12	31	31
24	76	67	72	78
30	93	91	97	94

SEASON OF 1897. Corrosive sublimate disinfection as in 1896; formalin disinfection by soaking tubers two hours in 1-607 formalin solution.

(Eight fluid ounces of 40 per cent. formalin [the usual commercial strength] to 15 gallons water.)

Number of days after planting.	PER CENT. OF TOTAL NUMBER OF PLANTS ABOVE GROUND AT FROM NINETEEN TO THIRTY DAYS FROM PLANTING.					
	Untreated.	Cor. Sub. on day of planting.	Cor. Sub. 44 days before planting.	Cor. Sub. 76 days before planting.	Formalin on day of planting.	Formalin 15 days before planting.
21	47	20	38	57	47	45
23	78	57	75	72	85	84

Final germination was practically perfect in all cases.

Everyone who has had experience in careful tests of potatoes will realize the large sources of error in field work of this character. Making full allowance for these and disregarding smaller differences there can be no doubt as to the correctness of the following conclusions:

*Bul. Ind. Exp. Sta., 56 (1895); Bul. do. 65, (1897).

1. Disinfecting with corrosive sublimate just before planting retarded the early growth of the plants both seasons.

2. Similar disinfection performed from one and one-half to three months before planting had no such effect.

3. Disinfecting with formalin had no retarding effect but apparently slightly stimulated growth.*

As already stated the slight injury here shown may not influence the ultimate stand of plants or the yield. We have had no appreciable evidence that it has done so in our plots except one year (1895.) Under some circumstances unquestionably it may do so. Moreover the amount of injury to the seed must naturally depend largely upon its condition at the time of treatment. If in the best of condition, that is with no sprouts started, the injury will be proportionately lessened. In our own cellar we are not able to keep potatoes from throwing out some sprouts and this should be taken into consideration in interpreting the results. The gain from the use of the disinfectant would in any case outweigh the possible losses.

Its use a month or more before planting time should remove all difficulty in any case. The relative effects upon subsequent growth of the formalin and of the corrosive sublimate solutions will lead us to prefer the former in case it proves equally effective in preventing scab as indicated by Arthur's experiments.

II. APPLE SCALD.

The apple crop of 1896 was a remarkably large one in Vermont, and there were numerous complaints that the fruit did not keep as well as usual. These facts led us to devote some time to the study of the causes of the decay of stored fruits, and, especially, of Greening apples. A number of troubles or diseases were commonly found contributing more or less actively to the destruction of the fruit, among them being the scab, the bitter rot, and the brown spot, the latter being especially troublesome on Baldwins. There was also a considerable disfigurement of fruit by hailstones during the heavy storm which occurred the latter part of August. It is interesting to note, however, that these bruises led to no hastened decay in any cases observed, save where the skin of the apple had been cut by the hailstones.

Another trouble, the serious occurrence of which in Vermont was first observed by us this year, is the fly speck fungus,† which often covered the fruit with its sooty blotches. These troubles were all of secondary importance, however, when compared with the so-called "scald."

THE SCALD.

This trouble, although widespread on Greenings, and generally known by this name, merits description that it may not be confused with some other

*Similar good effects were observed by Bolley (Bul. N. Dak. Exp. Sta., 27 (1896), p. 164), attending the germination of smutted grain treated with formalin in order to kill the ungus.

†*Leptothyrium pomi* M. & F.

malady. Greening apples which appear perfectly sound at time of harvest, will, at varying periods from midwinter on, become discolored. A light brownish tinge appears at first either in fairly well defined spots or more or less diffused over the surface. These discolored areas enlarge with more or less rapidity, fusing together until the entire surface of the apple may be involved. At the same time the color passes from a lighter to a dark brown shade, and usually terminates in a black rot. Upon cutting into the apple at the beginning of the trouble the flesh appears white and sound, the discoloration involving only the outer cells of the peel. As the trouble advances, however, the discoloration penetrates deeper into the flesh of the apple, and is soon followed in most cases by the fungus invasion, which we have just described as the black rot. This fungus is clearly a secondary affair, however, the primary discoloration being due to a breaking down of the tissues following their death from some cause other than the invasion of any fungus or other parasitic organism.

Our attention was first called to the serious occurrence of this trouble the past winter by Mr. T. L. Kinney, of South Hero, and at his invitation a visit was made to a number of the cellars and houses where Greenings were in storage in his vicinity. This was in February. In some cellars nearly the entire crop had been rendered unsalable, and was destined to early decay; in others scarcely a trace of the scald was seen. At first thought the trouble was deemed to be the result of improper conditions surrounding the stored fruit. Further comparisons showed, however, that this alone could not account for the entire difficulty.

There is much difference of opinion and a general lack of understanding among orchardists as to what the exact cause or causes are which are to be held primarily responsible. Doubtless they are numerous. Mr. Kinney believes that we must look for at least a portion of them in the conditions which surround the fruit before it is gathered, and others of our best practical orchardists are of simuar opinion.

ORCHARD CONDITIONS WHICH MAY LEAD TO THE SCALD.

Mr. Kinney's theory is that the apples are prepared to scald by conditions existing in the orchard, and he was able to show that the fruit in his vicinity freest from scald was from orchards where the trees were relatively the younger and the better situated, in brief, those in which the trees were in most vigorous condition.

Professor Bailey also is inclined to emphasize the responsibility of orchard conditions, and he states in correspondence that his observation has been that "the scald is worse when the fruit becomes rather over-ripe in the fall." He finds it "very bad when the falls are warm and dry, and the Greenings ripen up early."

Professor Goff, of Wisconsin, writes that his observations indicate that the scald has been much more prevalent in some seasons than in others.

Hon. George T. Powell, of Ghent, N. Y., has given much thought to the relation of orchard conditions to the keeping qualities of fruit, and lays much emphasis on the relation of scald to conditions preceding picking. We quote from a recent letter from him: "I am becoming convinced that the conditions before harvesting have much to do with the development of scald. If the season is one in which the fruit is steadily developed to the time of maturity without passing through extremes of temperature, that is normally developed, I think there will be little trouble from scald.

"For several years insects have very greatly injured the foliage of apple trees, fully one-half of the foliage has been destroyed by leaf-eating insects. As a result the fruit has been imperfectly grown, and it has been more susceptible to fungus attacks and early decay. Since I have been spraying to protect the foliage from fungus and insect attacks, my fruit ships much better, and I have less scald and decay. The past year was exceptional. From April 16 to 20, 1896, we had excessive heat, which brought vegetation forward unnaturally. Fruit matured during the hot weather of August and September, and it had poor keeping qualities. The Greening is one of the first of winter apples to mature, and it could neither be shipped to Europe nor kept in cold storage last winter successfully. If it is well grown it can be kept longer; if it is checked in its growth or is forced by continued hot or dry weather, it will scald before it decomposes. When perfectly grown I have seen it carry through a long period, and decompose without the development of scald. I have known the Greening to be kept two years in cold storage with no scald, but the fruit was perfectly grown."

Such testimony leaves no doubt as to the importance of using all practical means by fertilizing, cultivating, pruning and spraying, to bring the fruit to perfect maturity as the first step in the prevention of the scald.

There was, however, abundant evidence in the fruit cellars visited that the conditions surrounding the stored fruit have much to do, at least, in hastening or retarding the development of the scald.

RELATION OF CONDITIONS IN THE STORE-ROOM TO THE DEVELOPMENT OF THE SCALD.

In some of the cellars visited in February and March practically every Greening was scalded, while in others every apple was sound. In the case where the scald was worst the owner had been unable to keep the cellar at a sufficiently low temperature, and the excessive scald was, in his own opinion and in that of his neighbors, due to the high temperature. The one cellar visited which was entirely free from the scald was high and dry, with relatively less fruit in it and quite well ventilated. It should be noted, however, that the orchard from which this fruit was harvested was exceptionally well situated.

The relation of temperature and ventilation to scald is clearly shown in the fact of common observation that when the Greenings are stored in open barrels the scald, when it appears, shows first upon the fruit in the core of the barrel, and even when the fruit in the interior of the barrel is quite badly scalded, the upper layers for six inches or more may remain fresh and sound. Mr. H. D. Allen, of South Hero, states that when he has stacked barrels of Greenings in two tiers in his cellar, the fruit in the upper barrels was scalded worse than that below.

Mr. Kinney, whose storehouse was built with special reference to preserving uniformity of temperature and of ventilation, suffered considerably from scald during the past winter in spite of the fact that during the winter months he was able to hold the thermometer quite uniformly between 33° and 35°. He attributed his misfortune to conditions in the orchard as before stated, but observed some differences in amounts of scald in different portions of his house.

Through the kindness of Mr. S. A. Beach, of the New York State Station, we were placed in communication with Mr. T. B. Wilson, of Hall's Corners,N. Y., who has had a great deal of experience in handling Greening apples. He states that he has known Greenings kept in single barrels in a dry house cellar that did not show the scald by the first of April, while fruit from the same lot treated in the same way, except that the barrels were put in storage with many others, began to scald in January or February. He believes that in general a large lot of apples stored together will not keep as free from scald as will single barrels. He further writes that in his experience apples will scald much quicker if they are packed in the barrel immediately after picking and forced to sweat there than they will when allowed to sweat in a pile, and then after drying packed in the barrel. Mr. Wilson kindly outlined his method of handling the fruit with reference to lessening scald as follows: "We think the best place to sweat the apples is in the orchard. We put two or three inches of straw under the pile, and locate the pile in the shade, or at least so that the hot sun of the middle of the day cannot strike the apples. (Red apples we pile in the sun, and in that way get more color). The piles are made ten inches or a foot deep. The number of barrels in a pile does not matter. We place from five to forty barrels together as is most convenient, aiming not to make the pile too wide. They are usually left in the pile from two to three weeks. When we get them into storage we get the mercury, as soon as we can, down to about freezing, and aim to keep it as near that point as is possible." Mr. Wilson further believes that there is a possible advantage in shelving or crating Greenings while in storage instead of barreling them. He cites the experience of Mr. P. Gleason, of LeRoy, N. Y., who has had a considerable experience in this line, and who, by transferring Greenings from barrels to crates and stacking these crates in his cellar, has succeeded in keeping them from scalding much longer than when in barrels.

There is evident need of further comparison of practical methods along the lines suggested by the experience of Messrs. Wilson and Gleason, and it is hoped that those readers who have had such experience will write us regarding it.

III. OBSERVATIONS UPON OAT SMUT.

In the spring of 1895 seed oats were obtained from various western states and sown at this station in a series of plots in order to compare the relative amounts of smut developed under the changed climatic conditions. The seed harvested from each of these plots in 1895 was saved and again sown upon the same plot in 1896, the object being to continue the study of the original problem and more especially to see to what extent the smut would spread from one plot to another. The plots were each six feet wide, with two feet open space between.

The arrangement of the plots with the amounts of smut found in each in 1895 and in 1896 are as follows :

Source of Seed in 1895.	Variety.	Per cent. of smut, 1895.	Per cent. of smut, 1896.	Source of Seed in 1895.	Variety.	Per cent. of smut, 1895.	Per cent. of smut, 1896.
Vermont	White Schonan.....	4.7	12.4	Ohio	Mammoth Russian..	25.2	19.6
"	Black Oat.....	0.0	8.4	Vermont	White Schonan.....	7.6	6.6
"	Common White.....	4.7	12.3	Ohio	American Banner...	37.7	22.5
Indiana	White Schonan.....	3.8	19.9	"	Black Prolific.....	24.4	26.0
"	Black Prolific.....	8.1	25.5	Wisconsin		6.8	15.4
No. Dakota	No. 2	9.6	21.8	Wyoming	Bonanza.....	50.8	42.8
"	No. 4	19.7	20.7	So. Dakota	Dakota Grey.....	37.8	24.3
"	No. 3	26.8	28.1	"	White Wonder.....	32.6	62.5
Iowa		3.7	9.3	"	Jeannette Canadian.	3.6	4.4
Illinois	Pringle's Progress...	6.6	8.7	"	White Canadian.....	13.6	15.5
Michigan	American Banner...	4.1	9.9	Vermont	Black, Old Seed.....	0.8	7.7
Ohio	Race Horse.....	45.6	25.7	"	Common White.....	4.5	5.7
"	Black Norway.....	31.2	27.2	"	White Schonan.....	5.3	3.6

These results clearly show that the smut spreads rapidly from plot to plot under favorable circumstances. This is made more evident by comparing a few averages. Thus the average of all the plots shows 16.4 per cent. of smut for 1895 and 15.7 per cent. for 1896, a slight decrease in smuttiness. In contrast with this the average from all the plots sown with Vermont seed shows in 1895 3.9 per cent. while in 1896 the amount has increased to 8.1 per cent., or more than doubled., The amount of the disease in the very smutty plots showed a corresponding decrease; for example in the case of the seed obtained from Ohio the averages in 1895 were 34.6 per cent. while in 1896 they were 24.1 per cent.

The seed from each of these plots will be planted upon the same ground in 1897 that the results may be followed up year after year.

THE EFFECT OF THE JENSEN HOT WATER TREATMENT UPON THE YIELD OF OATS.

The various experimenters who have used the hot water method* have usually recorded considerable gains in yield as a result of the treatment over and above what might be expected from simply destroying the visible smut.†

It is an important fact if true that so simple a treatment will add materially to the yield of this grain. The reason for this supposed gain has remained in doubt, however, being most generally attributed to the fact that the treatment aids in the development of a ferment within the seed which favors the more vigorous growth of the seedling.‡

In all cases where this gain has been reported seed was used which contained a considerable per cent. of smut. In our own experiments to determine how great is the increase from this source we have used seed practically free from smut, and each season have found a loss rather than a gain from the disinfected seed. The tests of previous years|| were repeated in 1896 with similar results. The oat field contained four acres and was laid off in a series of parallel plots, alternate plots being planted with treated and untreated seed. The treated seed was soaked for 10 minutes in water held at 132°-133° F. and allowed to dry for 24 hours before sowing. The seed on all plots was carefully weighed so as to make allowance for the swelling and similar amounts of seed were sown in all cases.

The yields were as follows:

2 acres,	untreated	seed,	3600 pounds.
2 "	treated	"	3393 "

The difference is not great but adds further evidence that where seed perfectly free from smut is used there is no gain and may be a loss following the hot water treatment.

Recent investigations by Bolley§ lead him to attribute the gain which he has observed to the destruction of the smut fungus which may exist in the plants and decrease the yield without appearing in the grain.

*This consists in soaking the seed for 10 to 15 minutes in water held at a temperature of 132°-135° F. For details, see Rpt. Vt. Exp. Sta., 7 (1893), p. 61.

†See Bul. Kan. Exp. Sta. 22 (1891), p. 80. where Kellerman observed gains of from 3 to 8 bushels per acre, apparently attributable to some effects other than the destruction of the smut.

‡ See discussion by Dr. J. C. Arthur, Proc. A. A. A. S., 41 (1892), pp. 226-227.

||Rpt. Vt. Exp. Sta., 6 (1892), pp. 76-77.

§Bul. N. Dak. Exp. Sta., 27 (1897), pp. 119-120.

IV. THE ONION MILDEW.

The destructive occurrence of this mildew was noted in our last report (pp. 113-115), and its probable life-history discussed. Further observations during the spring and summer of 1896 confirmed the results obtained in 1895. The mildew again appeared where onions were sown upon infected garden soil, though owing to the weather conditions the disease was less destructive than in 1895.

1. LABORATORY STUDIES UPON THE FUNGUS.

All attempts at growing the fungus in culture failed as did also inoculation experiments. The circumstances were, however, unfavorable for this work owing to the distance of the diseased fields from the laboratories. The fungus produces two kinds of spores as was explained in our last report. Germination experiments show that the summer spores (conidia), which are produced in enormous numbers, are very short lived, so that it was impossible to get spores from leaves as ordinarily brought from the field to germinate. By placing some of the leaves in a moist chamber over night a fresh growth of the fungus was induced and spores taken directly therefrom germinated in water, each producing a single germ tube.

The fungus lives through the winter by means of resting or "winter" spores. These are thicker walled and formed in the latter part of the season. Examination of the onion leaves during the last week of August showed these spores to be then few and immature. They were much more abundant in leaves from the same field in the middle of September, showing that they are mostly formed during this month. These spores pass into the soil where the blighted onion leaves are allowed to remain in the field, as is commonly the custom, and germinating the following spring start the disease anew if onions are again planted on that soil. The fact of this soil infection was clearly shown experimentally by growing onions in our greenhouse during the winter of 1895-6. The seed was sown in December. At the same time a barrel of soil, secured the previous autumn from the surface of an onion field where the blight had occurred, was worked into the surface over one-half of the bench. In April the mildew appeared quite abundantly on this portion of the bench, but none occurred upon the other end. If pains are taken to remove all the leaves together with the bulbs from a field that has blighted it would seem quite possible to keep the soil practically free from the fungus. The leaves, of course, should be burned or otherwise destroyed. If the leaves and many bulbs are left on the ground the soil will become filled with the germs and the mildew will be certain to appear if the weather favors. Rotation of crops must then be practiced.

2. FIELD EXPERIMENTS WITH FUNGICIDES.

It seems to us that the destructive occurrence of the mildew can be largely prevented by the precautions explained above. In some cases, however, it may be impossible to prevent the recurrence of the disease, or there

may be danger of the fungus being carried by wind or insects from neighboring fields. In this case spraying is the hopeful remedial measure. In order to test the merits of various fungicides in checking the mildew a series of plots were sprayed or dusted three times with the following materials: Standard bordeaux mixture, standard bordeaux mixture and soap, potassium sulphide solution, flowers of sulphur.

Two great difficulties were met; first, the solutions do not adhere well to the erect glaucous leaves of the onion; second, bordeaux mixture of the strength used proved quite injurious to the onion leaves. As no mildew appeared on this field the fungicidal values were undetermined. It is probable that a weaker bordeaux mixture may prove less injurious. Mr. S. A. Beach of the New York State Station informs us that onions are successfully sprayed with bordeaux mixture by some New York growers.

V. THE ORANGE HAWKWEED OR "PAINT-BRUSH."

During the past few years the orange hawkweed has come prominently into notice in Vermont as a dangerous weed. On account of its rapid spread, utter uselessness, and thorough monopoly of the soil, it is at the present time the worst weed known in some sections of the state, and threatens to become still more widespread. In order to prevent this so far as possible the station has made a careful study* of the plant from the economic standpoint. The practical conclusions drawn were published in bulletin form during the winter. The following account contains the substance of the matter of this bulletin, together with the more technical descriptions of the plant, details of its history and distribution, and more complete accounts of the results of experimental work upon it.

Names. The plant has been known to botanists in Europe for nearly three centuries, and naturally has received many different names. It was first termed *Hieracium fuscum* by Villars, then *Hieracium aurantiacum* by Linnæus, by which name it is still known. It is commonly called "orange hawkweed" in America, which is a literal translation of its botanical name, in Germany it is known as the *Pomeranzenfarbiges Habichtskraut* or orange colored hawkweed, while its many black hairs have led English gardeners to call it "Mr. Collier," or "Grim the Collier."

Its showy character and rapid spread as a weed have suggested several other local names such as golden hawkweed, hawkweed, paintbrush, red paintbrush, ladies' paintbrush, flora's paintbrush, devil's paintbrush, red daisy, missionary weed, lion's tongue and tassel flower. It is most widely known as "orange hawkweed" or as "paintbrush" in this state, other names being less generally met.

*Mr. W. A. Orton, a senior student in the Agricultural Department of the University, made this the subject of his thesis investigation, and had personal charge of most of the work.



1. THE ORANGE HAWKWEED OR "PAINT-BRUSH."

Entire plant in flower, one-half natural size. This plant originated from the runner shown at the lower right hand corner. The two young runners at the left have already taken root, and will soon give rise in turn to new plants.

*Description.** *Hieracium aurantiacum* L Perennial, by slender root-stocks and numerous runners. Stem simple, erect, one to two feet high, densely hirsute, the hairs towards the apex of the stem black at the base. Leaves mostly radical, oblong lanceolate, slightly denticulate, hirsute on both sides; those of the stem two or three, all but the lowest reduced to bracts. Heads 5-30, in a bracted cyme; peduncles with long, straight multicellular hairs, black glandular hairs, and a close grey covering of stellate hairs; involucre about 85 mm. in diameter, its bracts linear-lanceolate, little imbricated, provided on the back with straight, glandular, and stellate hairs. Florets 60-75, all perfect, with ligulate corollas, flame-red at the outside, shading into orange at the center. Achenes 2-2.5 mm. long, 5 mm. wide, dark brown, linear in outline, terete, ten-ribbed, rough, often slightly curved, contracted at the top, forming a little cup on which the pappus is seated. Pappus consisting of numerous grayish rough bristles, two to three times the length of the achene, arranged in a circle around the outer edge of the top of the achene, in structure like the straight hairs on the leaf. Seed conforming closely to the interior of the achene, testa strong, membranous, white; endosperm absent. Embryo comparatively large, filling the whole seed, straight, white. Cotyledons linear, obtuse, entire, closely applied face to face. Radical terete, obtuse, shorter than the cotyledons, straight.

Seedling. Primary root tapering, flexuose, with numerous lateral branches which soon take its place. Hypocotyl bent on first germinating, then erect, glabrous, light-green. Cotyledons oblong-spatulate, tapering to a broad base, without any discernible venation. Stem with the primary internodes but little developed. Leaves, first pair simple, entire, opposite, ovate-oblong, pubescent on both sides, petiolate; second pair longer, winged petioled; third leaf oblong-lanceolate, slightly denticulate, tapering to a broad, slightly sheathing base, but not petioled; subsequent leaves alternate, similar to the last.

Habit of Growth. The plant is low growing, its leaves lying close to the ground. Its roots are perennial, small, fibrous and shallow. The habit of the plant is well shown in Fig. 1. The plant propagates itself vegetatively by means of stolons or creeping stems, which start from the axils of the lower leaves, and tend to grow downward, burying themselves just under the surface of the soil and becoming rhizomes. When thus growing just under ground they are nearly leafless, and are either white or of a light reddish tint; but when forced by circumstances to grow on the surface, exposed to the light, they become quite leafy and of a dark red color. Each stolon gives rise to a plant, and as this creeping stem is perennial, the plants remain connected with each other.

The stolons are produced very abundantly, in fact, they form the principal means of propagation. A count made in August showed twenty to thirty new plants starting by stolons during that season from a single old plant, situated in a favorable location. The new plants form a dense growth, completely covering the ground, driving out everything else. On account of this mode of growth it tends to form patches in fields.

*In part modified from Rpt. U. S. Dept. Agr., Div. Bot. (1890), p. 388.

The hawkweed is not, however, dependent on runners alone for propagation, for it produces abundant crops of fruit. It flowers the first year from seed, the first blossoms appearing in this latitude from the tenth to the sixteenth of June. The seeds mature before haying time, and become widely scattered in the hay. The same plant may flower and fruit several times in one season, so that a field of the weed appears in almost continuous blossom from June to November, and scatters seed with every wind. A single plant may produce from 1,000 to 1,500 fruits, each provided with a pappus of long hairs to aid dispersal by the wind.

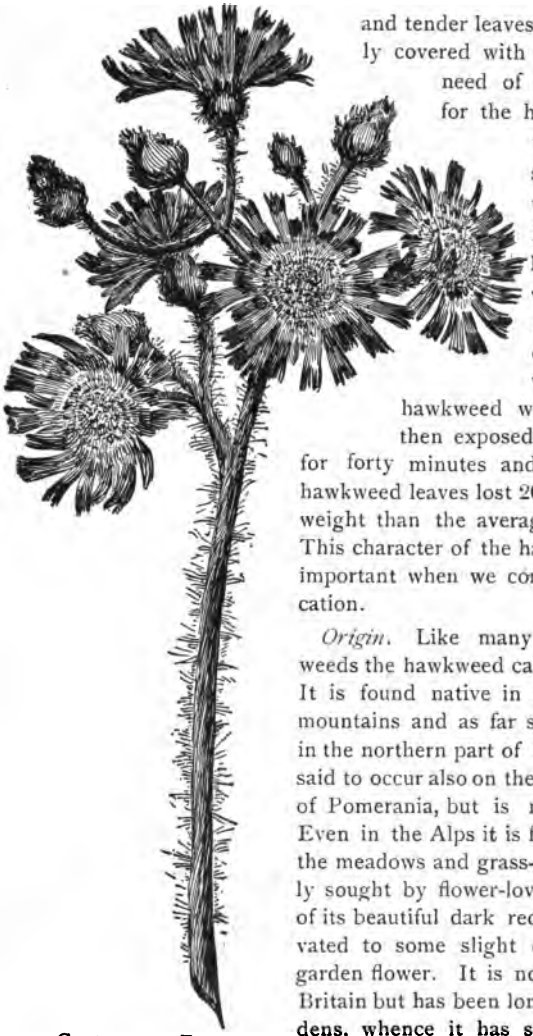
The seeds show decided viability when fresh, and a considerable proportion germinate the first season if favorable conditions are met. In ground adjoining a field of hawkweed which had been allowed to go to seed in 1896, all the vacant spaces were completely filled with the little seedlings, showing that there may be rapid spread by seeds.

Germination tests have shown that the seeds early lose their viability. The following figures show the results of recent tests at this station:

Fresh	60	per cent.	germinated.
One year old	44	"	"
Two years old	35	"	"
Three " "	16	"	"
Five " "	0	"	"

These results obtained with seeds carefully kept from extremes of heat and cold suggest the probability that hawkweed seeds when exposed to the vicissitudes of winter and summer in their natural resting places are comparatively short lived. We may not expect to find several means for propagation reaching their highest development in the same species. The hawkweed has the system of propagation by stolons so highly developed that seeding is becoming a secondary method with it, as it has already become with the Canada thistle.

Structure. The structure of the hawkweed is not materially different from that of other plants of the same class. Its leaves are rather thin and the whole plant is densely hairy. The hairs are of three forms, straight, glandular, and stellate. The first form is the most prominent, being found on every part of the plant which is exposed to light. They are very long, and being filled with air are light colored. The capitate or glandular hairs are found on the stem, and on the peduncles and involucres of the flower heads. They are most numerous near the flowers. The stellate hairs are found on the under side of the leaves, on the stem and on the involucres. They consist of a stalk of four or five simple cells, with a much branched terminal cell or cells filled with air. These hairs protect the plant in several ways. (1) They tend to render the plant distasteful to animals. (2) The hairs on the stem prevent crawling insects from reaching the flowers. (3) They retard transpiration, since being filled with air they shade the epidermis, and protect it from the heat and light of the sun. This is especially the case with the young



2. CLUSTER OF FLOWERS. (Natural size.)

and tender leaves which are most densely covered with long hairs. There is need of some such protection, for the hawkweed is not otherwise adapted to withstand hot, dry conditions. It is one of the first plants to wilt from lack of water and loses water more rapidly than most other plants. Several leaves of hardy weed plants and of hawkweed were weighed carefully, then exposed to the heat of the sun for forty minutes and again weighed. The hawkweed leaves lost 20 per cent. more of their weight than the average of the other plants. This character of the hawkweed becomes very important when we come to consider its eradication.

Origin. Like many others of our worst weeds the hawkweed came to us from Europe.* It is found native in Norway, in the Alpine mountains and as far south as the mountains in the northern part of Italy and Spain. It is said to occur also on the moors of Hanover and of Pomerania, but is nowhere very common. Even in the Alps it is found but sparingly in the meadows and grass-plots, where it is eagerly sought by flower-loving tourists on account of its beautiful dark red flowers. It is cultivated to some slight extent in Europe as a garden flower. It is not indigenous in Great Britain but has been long used in cottage gardens, whence it has sparingly escaped into copses and woods in various places.

From these statements it is evident that it has not shown the characters of a serious weed in any case either in England or on the continent of Europe. It is difficult to understand why the plant is a weed in its adopted home and

*Our thanks are especially due to Professor Carruthers, of England, and Doctors Stebler, of Switzerland, and Nobbe, of Saxony, for information concerning the occurrence of the plant in Europe.

shows no such tendencies in its native habitat. Indeed, when one considers its methods of propagation, the question is not why it is a weed in the northeastern United States but rather why does it not become a weed wherever it grows. Such occurrences are, however, not uncommon. Other cases might be cited of harmless plants becoming weeds on introduction to another climate, and not infrequently insects which cause little trouble in their native home become serious pests when brought to another country. This may be in part accounted for by the absence in the new home of those enemies, insect and fungus, which seemed to hold it in check in its native country. Moreover the changed equilibrium of the forces acting upon the plant from within and without impel it to adapt itself to its new environments and frequently to acquire greater variability and adaptability, qualities most needful for its successful existence as a weed.

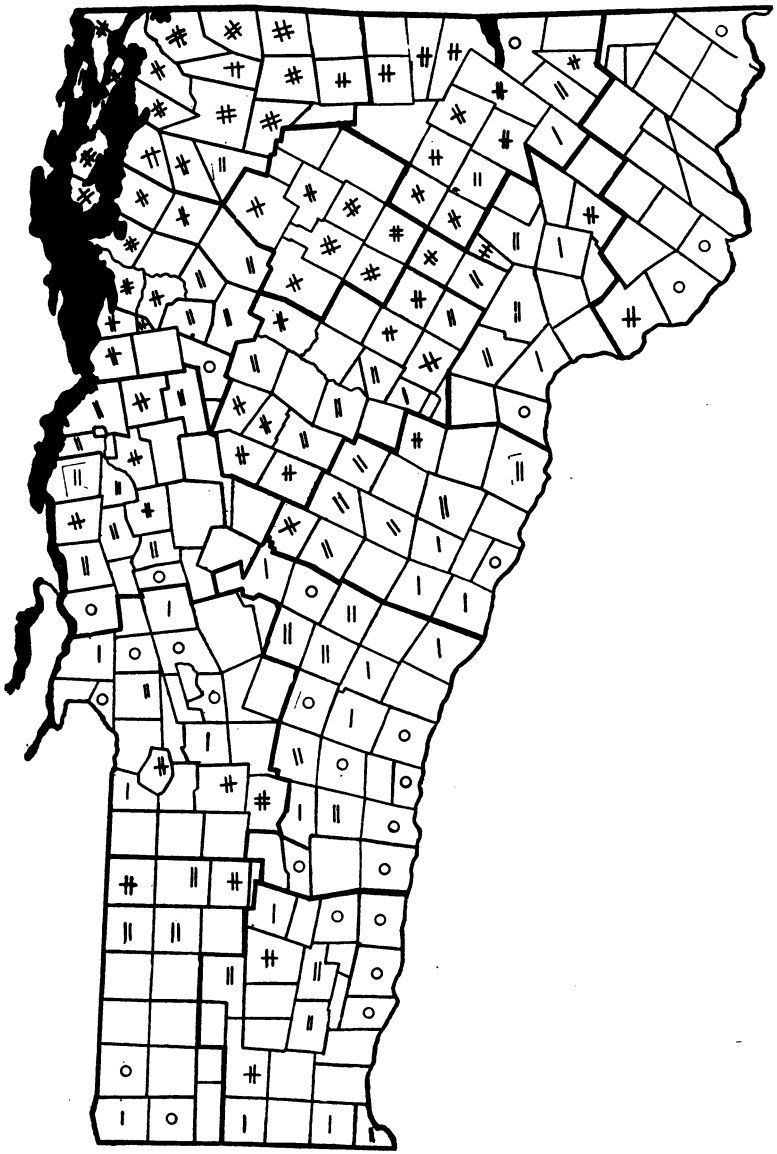
The hawkweed is known to have been in America for over fifty years without appearing as a weed, during which time it may have been varying and adapting itself to its new environment.

Introduction into America. The hawkweed was brought to America as a garden flower early in the present century, the exact date of its introduction being unknown. It is first referred to as a cultivated plant in an American publication in 1818.*

No reference has been found to its exhibition of weedy tendencies prior to sometime between 1860 and 1875. Attention appears to have been called to its escape from the garden and its dangerous character as a weed for the first time in August, 1881,† by Mr. W. H. Lennon, of Brockport, N. Y. A month later Thomas Meehan writes:‡ "I have had it sent to me several times from correspondents in the Eastern States during the past 20 years," and, later,§ "Mr. Chas. J. Sprague, of Boston, found it in the summer of 1880 in St. Albans, Vt., covering large patches of bare hilltops where the grass was thin and scant and in what appeared to be old fields where it seemed to have taken full possession." Mr. C. G. Pringle, of Charlotte, Vt., states that he first saw the hawkweed outside the garden in 1873, growing by the roadside near Shelburne Falls, Vt. This is about the time it was noticed first in Rhode Island and other places. From this time on notices of its occurrence and its weedy propensities are more frequent, indicating that the hawkweed began its rapid spread in the early seventies.

The hawkweed has never been very extensively cultivated in this country and is not now catalogued by our principal seedsmen, from but one of whom could seed be obtained this year. There is no doubt, however, that hawkweed was distributed throughout New England in the seventies by seedsmen and through its use as a premium by an agricultural journal.

*Eaton, Manual of Botany, 2nd Ed. (1818), p. 272.
†Bot. Gaz. 6 (Aug. 1881), p. 248.
‡Ibid. 6 (Sept. 1881), p. 265.
§Ibid. 7 (Jan. 1882), p. 7.



3. THE DISTRIBUTION OF THE ORANGE HAWKWEED IN VERMONT.

As reported to the Experiment Station in June, 1897. No reports received from towns not marked.

Meaning of the marks:—The circle (O) indicates that the hawkweed has not been seen; one line (|) indicates that it occurs but sparingly; two lines, (‖) that it is well scattered but not yet recognized as a bad weed; three lines, (⧺) that it is well established as a weed; four lines (the double cross) that it is a very bad weed.

Letters of inquiry were sent during the summer of 1896 to leading farmers in all parts of the State asking about the occurrence of the hawkweed, time and mode of introduction, its character as a weed, rapidity of spread, soil conditions most favorable, experience in eradication, etc.

Two hundred replies were received. The plant was reported a serious weed by 122, as occuring sparingly by 35, and was not known in the locality by 40. It was stated to be spreading rapidly by 100 and to be making but slow progress by 54. Its method of introduction was stated to be as a garden flower by 40, in grass seed by 7, by wind and birds by 10 and by other means by 5. The distribution of the hawkweed in Vermont as learned from these inquiries is indicated by the map on the opposite page.

It is most troublesome in the northwestern portion of the state. Franklin, Grand Isle, Lamoille, Orleans and Chittenden counties are thoroughly infested with it, and it is widely introduced in the remaining portions of the state, though in many cases not as yet recognized as a serious weed. The spread of the weed into parts of the state where it is not now known is probably only a question of time.

Outside of Vermont the hawkweed occurs as a dangerous weed in Maine, New York, Northern Pennsylvania and Eastern Quebec, and is known to occur, though not as yet troublesome as a weed, in New Hampshire, Massachusetts, Rhode Island, Connecticut, New Jersey, Eastern Pennsylvania, Ashtabula county, Ohio, and Michigan.

In its spread in Vermont as well as elsewhere it has shown a preference for a cool climate and the higher altitudes, conditions similar to those of its home in the mountains of Europe; but as already suggested it seems to be in a measure changing these tendencies. It has been reported as thriving in all soils and almost all locations from sandy fields to the heaviest undrained clay, and from the rocky sides of the Green Mountains to the fertile shores of Lake Champlain. No soil is too poor and none too rich for its successful invasion.

Reports like the following are numerous: "My farm is now one complete mass of the weed. It was first brought there in 1886 or 1887 as a flower, and spread in spite of all effort to check it, until today it has nearly ruined the whole locality." "It will soon drive everything out of some pastures in this town if it is not checked." "It is spreading rapidly, and completely runs out all grass." "Some pieces of land are ruined by the wild carrot, but I think the paintbrush will beat them all if it is not kept down." Many more statements might be cited which place the hawkweed first in the list of bad weeds in Northern Vermont. Such reports come, however, largely from farmers having hill pastures or meadows which do not admit of thorough cultivation. This weed ought never to prove very troublesome in tillable land where the soil can be kept fertile and short rotations practiced. But in the lawns and roadsides, in neglected fields and hill pastures, where it can have plenty of time to establish itself, and where cultivation cannot be practiced it is proving to be the worst weed which has as yet invaded Vermont.

Eradication. It seems scarcely necessary to say that where this weed is not already present precautions should be taken to prevent its introduction. Hay and manure from infested lands should be avoided. If it is allowed to establish itself by roadsides and in waste places, it will soon spread to the neighboring fields. Such plants should not be allowed to form seeds in any case, and as far as possible should be eradicated. The first and most important means of fighting any weed where it is possible to practice it is

Cultivation. It is obvious that a plant with runners and rootstocks like the hawkweed cannot be combated by hand pulling. Such attempts leave numerous rootstocks in the soil and will at best give the weed but a temporary set back. For the same reason cutting off the plants with a hoe is not likely to be successful unless followed up repeatedly.



4. THE HAWKWEED IN FRUIT.
Three hundred seeds ready to sail away on the next breeze.

The hawkweed readily yields to careful plowing followed by thorough cultivation. We have found by experiment that it is possible practically to exterminate the plant in one year in this way. In one case, late fall plowing in a dry field, followed by a little cultivation and dry weather during the following spring destroyed the weed entirely. In general practice, however, a year or two of thorough cultivation should be given to insure the best results.

Salt. The hawkweed is often most troublesome in places where cultivation is impossible on account of the nature of the ground. Cultivation is undesirable, moreover, when the weed exists in small patches. A very effective remedy is found for such cases in *salt.* This agent has long been used in fighting weeds but in most cases such heavy applications are required as to destroy the grass and other useful plants along with the weeds.

The hawkweed, however, is peculiarly sensitive to the action of salt. It is quickly killed by an application which leaves the grass uninjured or sometimes even benefited.

Adjoining plots were staked out in a field badly infested with the weed and dry salt was sown broadcast at the rates respectively of 2,000, 3,000, 5,000, and 10,000 pounds per acre. The heaviest application entirely destroyed both hawkweed and grass. *All of the lighter applications proved ultimately beneficial to the grass* and in varying degree destructive to the weed. Most of the weed was killed by the application of a ton to the acre and *it was entirely killed when a ton and a half to the acre was used.* These applications were made May first. Two months later the grass (meadow fescue) upon the salted plots was noticeably larger and of a richer darker green than was that on the adjoining soil where no salt had been applied. Ten plants of the grass from the unsalted plot weighed 14 grams while ten from the salted plot weighed 26 grams or nearly twice as much. (See Fig. 5, p. 72). It was noticeable, moreover, that the grass grew more rankly during the following season on the salted area.

Repeated trials have proved that where the weed is thoroughly established so as to cover the entire ground 18 pounds of salt per square rod or 3,000 pounds per acre is sufficient to destroy every plant of the hawkweed. In all cases upon our soil such applications of salt benefited grass in the end but injured or killed clover. White clover was injured much more than red clover. When the weeds are scattered much less salt will suffice. If but a few plants occur a small handful of salt scattered over the leaves will prove sufficient.

It should not be inferred that similar applications of salt will prove equally beneficial by doubling the grass yield on all soils and under all circumstances. Salt acts as a fertilizer on land, not because of any plant food it contains, but, among other reasons, because it may so act on the insoluble elements already in the soil as to render them more soluble and hence more readily available to the plant. Salt will therefore prove more beneficial on some soils than on others. It seems probable from our experiments, however, that this weed may be destroyed in any soil by applications of salt in amounts which will be more likely to prove beneficial than injurious to the grass. Salt was applied at the rate of 3,000 pounds per acre to one field completely filled with the hawkweed and soon after the land was plowed and seeded to grass. The salt destroyed practically all the weed and appeared in no way injurious to the new seeding, the stand of grass this season being quite as good on the salted ground as on that adjoining which was not salted.

Two questions naturally arise at this point, first, what is the explanation of the action of the salt in killing the hawkweed? and, second, why is it more susceptible to this destructive action than are other plants? Unquestionably the chief if not the entire cause of the fatal action of the



5. THE RELATIVE EFFECTS OF SALT AND OF HAWKWEED ON GRASS.

The cluster at the right grew in the midst of hawkweed; that at the left was similarly situated except that 3,000 pounds per acre of salt had been applied, the result being the entire destruction of the weed and the doubling in weight of the grass.

salt, is to be found in its activity in withdrawing the water from the plant. When dry salt is sprinkled upon hawkweed foliage it soon draws enough water from it to dissolve the salt, and the leaves wilt and ultimately die.

This explanation is in accord with the important practical fact that *salt is more destructive to this weed when applied during hot, dry weather than when used during wet weather ;* moreover, the *dry salt kills the weed quicker than brine.* Brine applied at the same rate as dry salt, (3,000 pounds per acre) to ground filled with hawkweed was found to give the plants a set back, because the leaves were killed, but new foliage was rapidly developed and the plants grew as thickly as before the application.

The cheaper coarse "agricultural salt" has proved quite as effective as the finer table salt in our experiments, and is of course recommended for use. Such salt costs in Vermont from $3.50 to $5.50 per ton, rendering its use in fighting the weed entirely practicable.

It is interesting to note that some of the more soluble chemicals used in the manufacture of commercial fertilizers may be used to kill this weed in the same way as salt, though none are so active in this respect. Kainit, muriate of potash, sulphate of potash, and nitrate of soda have proved most effective in our experiments. The amounts required, however, involve an expense too great to make their use wise under most circumstances. Other chemicals, notably sulphuric acid and carbolic acid, kill the weed quickly, but their greater cost and poisonous nature render their use undesirable as compared with that of salt. Kerosene proved inferior to salt.

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REPORT OF THE ENTOMOLOGIST.

G. H. PERKINS.

THE RED SPIDER.

Tetranychus telarius, Linn.

The mite commonly known as the red spider has long been a very troublesome pest in Europe and appears to have been introduced upon imported plants into this country at an early period. Though best known as a greenhouse pest, it does no little damage to plants and trees growing out of doors. When it does not actually destroy the plants which it infests it greatly damages them in appearance and weakens their vitality by feeding upon the sap. It is very probable that no small part of the blighting and disfiguring of the foliage of garden plants which is supposed to be due to some other cause is really the work of the red spider. It is one of those extremely troublesome insects which does not confine its depredations to a few, or a single species of plant, but is a very general feeder; indeed I do not know of any sort of vegetation which is distasteful to it. On this account it is the more difficult to exterminate it when once it has made its appearance.

It has been reported as injurious, often to a ruinous extent, in orchards and nurseries where it has attacked plum, peach, pear, quince, larch, cedar and other trees. Grapes, especially when under glass, sometimes suffer greatly from the red spider. Perhaps its ravages have been more widely noticed when the attack was upon flowering plants in gardens or greenhouses. The moisture, temperature, etc. of the surrounding atmosphere seem to concern this insect more than the particular species of plant upon which it has located. And yet there is I think, undoubtedly, much that is erroneous in the common belief of florists respecting the effects of moisture upon the red spider. The universal and long held idea is that a warm, dry air is favorable, and a cool, moist air, unfavorable, or even fatal, to this insect. With some modification this is true. A dry air is more agreeable to the insect than an atmosphere filled with moisture, and warmth is much more favorable to its development than cold, but a considerable degree of cold can be borne without fatal consequences, though the growth and development of the species are retarded by exposure to cool air. As to moisture, however, we must disagree with the common opinion that in any considerable amount it is fatal to the red spider or even necessarily injurious, as will be shown later. Perhaps there are no conditions which are more favorable to the rapid development and increase of the insect than those commonly found in greenhouses, although as compared with outside air, that of these places is not dry. Still, when moved from the greenhouse to the open air, plants often become quite free from the pest, although plants growing in garden beds

may be much infested. It is not the intention of the writer to deny that a warm, dry atmosphere is often very favorable to the insect. This seems to be true and the belief is strongly corroborated by the fact that orchards and nurseries on the Pacific coast, where there is a long, dry season, are much more seriously affected than those of the east. This may be mainly due to our changeable climate and extremes of temperature. I am quite inclined to believe that it is.

LIFE HISTORY.

Name. In speaking of this mite I have used the term *red spider* because it has been long and universally known as such and the name cannot be conveniently set aside but must remain the popular designation of the insect. The name "spider" is not, however, quite correct, for, although closely allied to the spiders, it is not a spider, but a mite, as may be seen by anyone who will take the trouble to examine it with a tolerably strong lens. As every one knows, in spiders the body is clearly divided into two parts which are joined often only by a very slender tubular portion. The mites have no such separation, but the body is undivided and is usually more broadly oval than that of the spiders. Both have eight legs, at least when fully grown, simple eyes, if there are any, and mouth parts which pierce and suck the juice of animals or plants. The general form and appearance of the red spider, as I shall continue to call it out of deference to long usage, is seen as it appears when highly magnified in the figures on page 79.

Color. Not only is the term "spider" incorrect as applied to these mites, but "red" is not much more accurate for, while red or scarlet individuals are found, sometimes very abundantly, red is by no means the only color and often it is the exception rather than the rule to find specimens of this hue. The color varies with the food plant upon which the insect lives and with the age of the individual. Upon some plants red mites may be most numerous, but upon others there will be few reds, but many greens or browns of various shades. The color, whatever it is, may grow darker with age. When the young come from the egg they are light yellowish or whitish; later two red spots appear on each side of the back near the head. This may be all the red developed, or it may extend over the whole body, or, by the increasing depth of color, as the body grows darker these spots may be obliterated.

It has been noticed that the food appears to have much influence upon the color. Upon some plants all the mites will be of nearly the same color, while upon others a variety of hues will be found. The males are often lighter than the females and the old females are darker than others, some being almost black.

Web. Unlike the true spiders, the mites do not usually produce a web, but some do and the red spider is one of these. Its web, like that of the spider, is secreted in the body as a fluid which is forced through tubes of exceeding delicacy in fine streams which harden, as they reach the air, into the silken thread with which we are so familiar. The thread of the red spider is so fine

that it is necessary to use a strong magnifying glass to see it. Many of them together, however, are visible as a sort of sheen on the underside of a much infested leaf. The web may extend from leaf to stem or from one leaf to another and under this the mites, old and young, are sheltered. They are most commonly found on the underside of the leaves of plants, covering the whole, if there are many, or along the midrib if but few are present. On badly infested plants they do not confine themselves to the underside of the leaf, though still remaining there in greatest numbers, but may be found on the upper side of the leaves and on the stems and branches.

When my attention was first directed to the red spider about ten years ago, I supposed that an insect known so long and so well would be frequently mentioned and its life history given in many entomological works. I soon found that this was not the case and that, aside from brief notices of little value so far as the history and development of the species goes, almost nothing had been published with the exception of the work of Claparede, *Studien an Akariden*, which has never, so far as I can discover, been translated and which is almost wholly inaccessible to most students. For this reason it has seemed to me well to devote this report to the red spider and to such remedies as may be suggested for its destruction.

For a large part of that which follows I am indebted to the notes of my much lamented friend, the late Dr. J. H. Worcester, who undertook a long series of very careful investigations, the results of which are given hereafter. Those acquainted with Dr. Worcester need not be told of the careful, thorough, patient work which he did. Some of this was done by Dr. Worcester and myself together, much by him alone, and many results have been verified by my own investigations. The following pages give the combined results of our work.

Methods of Observation. In order that the natural development of the red spider might be affected as little as possible, the leaves on which they were living were left, so far as practicable, undisturbed, and the mites were studied for the most part in situ. Either the leaves were brought under the microscope without detaching them from the plant upon which they grew, or, and most frequently, they were, as soon as removed, placed upon the slide over a small dish of water and when not under the lens were covered with a bell glass. By isolating particular leaves the same group of eggs or mites could be studied for several days or as long as the leaf selected remained in such condition that the insects could thrive. When everything was properly arranged the leaves continued in good condition for two weeks.

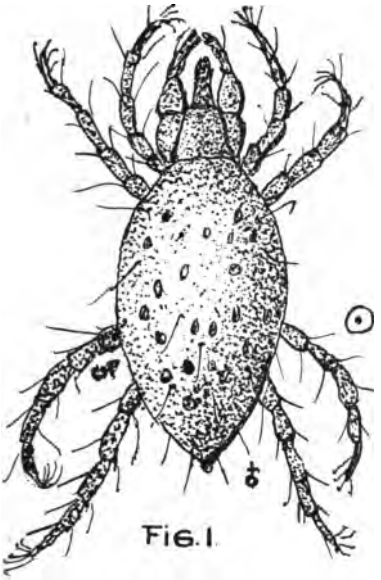
Movements. The restless disposition of the insect interferes considerably with the continuous study of its habits for it is often very difficult to isolate a few individuals and to keep them separate until all stages of growth and development are completed. Either the mites set apart for investigation disappear in the most unaccountable manner or there

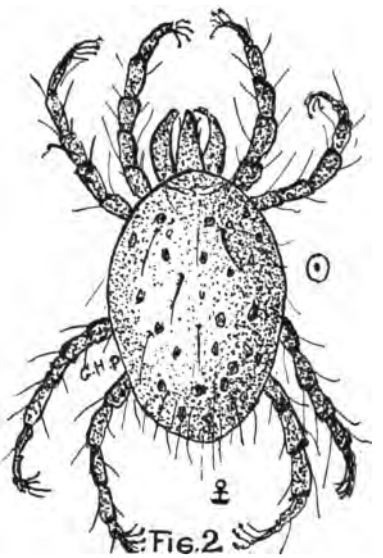
may be a sudden immigration of a company of others which speedily mingle with the subjects of study so that they can no longer be identified. The social and migratory habits of the red spider were continually manifested in many interesting forms. Dr. Worcester found that as a rule the female, after she had begun to lay eggs, remained by them until the full complement was produced, but so soon as the young were hatched she was off. The young mites usually scattered over the leaf or to other leaves as soon as hatched, although occasionally they remained until after the first moult; but none were observed to remain longer. They showed considerable skill in making their escape, for often the slide, upon which the leaf they inhabited was placed, was laid upon a small support in a dish of water so that their only way out was over what, to them, was a large lake, yet they often managed to cross it and escape; at any rate they could not be found. Notwithstanding these difficulties, by the exercise of care and patience the life history can be quite satisfactorily made out.

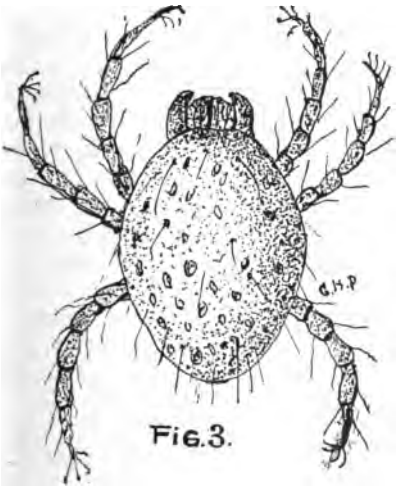
Eggs. The eggs are relatively large, spherical, colorless or light yellow. They are laid at intervals for several days, the duration of oviposition varying with the conditions that may exist. It sometimes lasts ten or twelve days, the latter being the longest period noted. The average and usual period is about seven days, and it often continues until the first eggs are hatched and the larvæ have moulted several times. The number of eggs laid each day is very irregular. On some days none were laid, on some one, two or three, and so on up to eight, which is the largest number observed. In warm weather, when all was favorable, the eggs hatched in a week, but if cooler weather came they did not hatch for ten or twelve days, or even longer. I think sixteen days was the longest period noted.

Larva. The newly hatched mite is, (Figure 3), an oval, six legged insect of light yellowish or reddish color. At this time no sexual differences appear to an ordinary observer. In about two days the young mites become quiet and the color grows darker. In this quiescent condition the larva remains two days, then it casts its first skin, gets a new one, and moreover, adds two legs making eight in all. A second moulting occurs after two days, and a third follows two days later. After the second moult the sexual characters begin to appear and before the last moult they have so far developed that the already fully formed males easily recognize the females and wait, it may be for hours, for them to cast the old skin and come out as perfectly developed mites. The male will even assist his prospective mate to escape from the old skin. I do not know whether it is always the case, but so far as was observed, the skin when about to come off at moulting is split transversely, the two front pairs of legs going with one half and the two posterior with the other. The cast skins are light or white and when numerous they appear as a whitish coating on the leaf, especially on either side of the midrib.

Reproduction. The sexes pair at once after the last moult, and one female may receive several males if they are at hand. Probably, as with spiders, bees, and other insects, impregnation occurs but once, the eggs being after-









TETRANYCHUS TELARIUS, L. RED SPIDER.

Fig. 1, Mature male. Fig. 2, Mature female. Fig. 3, Recently hatched, six legged larva. Fig. 4, Last joint of leg. Original. All the figures are very greatly enlarged. The dot, within the circle by the side of Figs. 1 and 2, shows approximately the natural size.

NOTE.—The only published figure of a male so far as I know, is that of Claparede, which has been several times copied by authors. This figure represents the body as more pyriform than it is in my figure, but I have given it as it appears in most of the males which I have seen.

wards fertilized from the stored seminal fluid as they are laid. After the last moult there is no difficulty in recognizing males and females. As may be seen in figures 1 and 2, not only does the male differ in form from the female, being more slender and less regularly oval, but he is somewhat smaller, and lighter in color. It was not very satisfactorily ascertained how long the males live after pairing, but the female under favorable circumstances may live at least three weeks and probably longer. In warm, dry weather, the female begins to lay in about forty-eight hours after the last moult, but in cool weather she may not begin for several days or even a week. From the laying of the egg to the maturity of the female the time varies very greatly. It may, if everything is favorable, require not more than two weeks, but usually the time is longer and may be nearly three weeks. Of course in a temperate climate those red spiders which infest plants growing out of doors must perish with the first frost and can thrive only during the summer, but in greenhouses or anywhere under the protection of a roof they are independent of seasons and are laying eggs at all times.

While usually very ready to pair, if no male is near at the time she becomes mature, the female may without fertilization produce eggs. From these hatch only males and this goes on until the first laid eggs mature, and then, of course, males are present and ordinary impregnation occurs, after which both males and females are produced. Sometimes a parthenogenetic female after producing all male eggs, will, when impregnated, produce a majority of female eggs.

In pairing the male crawls under the female and raises the end of his abdomen to a point a little in front of the end of her body. If several males are present each takes his turn without quarrelling usually, until at last the female runs away and does not allow the approach of other males. There appears to be some relation between the color of the female and her fertility, the light colored and scarlet females being less fruitful than those of darker color. Some of these light females lay no eggs, some a small number, which do not all hatch, while many of the mites which do hatch from such eggs are weak and short lived. These light mites seem, however, to live longer than those which are more fertile for, while the average life of a fertile female is probably not more than three weeks, one scarlet female lived, counting from the last moult, forty-one days, another, seventy-four, others seventy-six and seventy-nine, and one, eighty-eight days.

The usual disposition of the red spider is friendly and peaceable. They are obviously fond of each other's society and rarely exhibit any temper or difference of opinion. Sometimes, however, a very curious contest, if it is that, may be seen between two males. I will give an account of one of these as copied verbatim from Dr. Worcester's notes.

"For the most part the males are very peaceable, even in the presence of the female, whose favors both are seeking. But occasionally I have seen one male chase away another which did not think best to contend, but did

not run far, as there was no pursuit. Sometimes, however, there was apparently a fight. At first I noted only that they stood opposite each other, very near, face to face. Then one would suddenly dart at the other, then as suddenly spring back. I looked to see them grapple and bite each other, but there was nothing of the sort. Indeed I do not suppose that they have any apparatus to bite with. Presently I caught sight of a sudden momentary gleam of light like a minute flash of lightning, passing between them; and finally I made out that they were using their tongues or suction tubes, which gleamed with a sudden flash as they were quickly thrust out and as quickly withdrawn. Finally I saw them apparently grapple by their tongues, and pull back as if each were trying to pull each the other's tongue by the roots. But I could never see that any lasting harm resulted, though sometimes one of the two would seem to have had enough of it, and would withdraw as it were for repairs, thrusting out and drawing in his tube by himself, as if it gave him some pain and needed a little nursing. In a short time he was running about again. Sometimes two spiders seemed to have a special spite against each other, and whenever they met a more or less decided contest would ensue. But these were only occasional phenomena. In general, the communities of spiders, young and old, male and female, seem to dwell together in perfect harmony."

Summary. The following summary gives, in condensed form, the principal facts embodied in the foregoing pages:

The light colored, spherical egg hatches, in warm weather, in about a week.

The young red spider has at first six legs, which become eight after the first moult.

There are three moults, which together occupy a week or longer. As soon as the third moult is effected, impregnation occurs if a male is present, if not, unfertilized eggs are laid which produce only males.

The males and females are readily distinguished if one uses a magnifying glass by their different forms and by the smaller size, and often lighter color of the males.

The first eggs are laid within forty-eight hours after pairing, if the weather is warm.

The female lays from five to eight eggs daily, if the conditions are favorable; if not, she lays only one or two, or none.

She continues to lay during at least three weeks, producing in that time a total of from fifty to a hundred eggs. One impregnation serves for life.

The following actual observation, one of many, I give verbatim from Dr. Worcester's notes, as it illustrates some of the points just enumerated:

"Dec. 28 I took a piece of leaf on which there was no spider or egg to a leaf on which there were a large number of eggs hatching daily. In a few hours I had on the new leaf five or six larvæ, and then I removed the old leaf. Dec. 29 I found five larvæ all active. Dec. 31 there were five all fixed,

that is in process of moulting. Jan. 2 there were five all free, Jan. 4 five all fixed. Jan. 5 and 6 I was away, but Jan. 7 I found them all fixed again, Jan. 9 all free and all females." From the above we get some idea of the moulting periods. Of course this alone would not give the number of moults, nor anything except the two days interval between the moults. It is given merely as a sample of the simplest kind of observation from hundreds of which the results here given have been gained.

REMEDIES.

The question now arises, what bearing has a knowledge of the life history of the red spider upon various methods which have been proposed for its destruction? It is not to be supposed that any pest could so long infest cultivated plants, and no remedy be suggested. Many have been proposed, and to some of them we now turn our attention.

Water vapor. Probably no method of checking the ravages of the red spider has met with such favor or been so long in use as a free sprinkling with water. Many, I presume it is safe to say most, experienced florists unhesitatingly assert that increasing the moisture in the atmosphere of a greenhouse is fatal to the red spider. I suppose that some foundation for such a belief must exist, but, as will be presently shown, our investigations did not enable us to discover it. It is very certain that the insect is able to endure a large amount of moisture without harm, at least under some circumstances, and we found no case in which moisture was fatal or apparently injurious. In order to keep fresh the leaves on which the colonies we were studying were located, they were constantly, and often for some days, surrounded by a very moist atmosphere. The red spiders in no case appear to suffer from this exposure to the supposedly fatal moist air. The leaves were often kept moist until so far injured by mold and decay that they could no longer supply proper food for their visitors, and not until that time arrived did the mites show signs of injury. They often might be seen creeping about through the filaments of mold as lively as ever. But more than this was given them without destroying their vitality. Dr. Worcester submerged several leaves covered with red spiders. After twenty-four hours of submergence the leaves were removed from the water. At first all the spiders were inactive and apparently dead, but in about an hour they all revived. After leaves had been under water forty-eight hours the red spiders likewise revived, but only after a longer time, in some cases two hours elapsing before signs of life appeared. From these experiments it would not seem to be possible to destroy the red spider by the simple addition of moisture in the air, certainly not, as has been more than once recommended, by sprinkling the walks and benches of the infested greenhouse in order to increase the water vapor in the atmosphere. Experiments were tried in another way to verify or refute the idea that the pest could be destroyed by water in the air or on the infested plants. Not only, as has already been stated, were infested leaves continually exposed to moisture by being attached to glass slides, which were

placed over vessels of water in order that leaves or branches might not wither, but in order to have a fully saturated atmosphere this water over which the slide was placed was removed, and hot water poured in, a bell-glass covering the whole. From time to time this water was replaced by hot water, so that the air was kept as completely saturated as possible. This was continued for several days, long enough as it was believed to fully test the effect of moisture, and in no case was there apparent injury done to the red spiders. In other experiments leaves were kept for several weeks in water in well stoppered bottles, and the red spiders were not only not injured, but laid their eggs which hatched, and the larvæ grew, all in apparent good condition. The number of these experiments was such that to the mind of both Dr. Worcester and myself the test was decisive. First and last many hundreds of red spiders must have been observed under conditions of moisture that would seldom be found in nature or in greenhouses, and in no single case was the moisture found to be seriously injurious to the insect, if, indeed, it was injurious at all. Of course it is recognized that, so far as dry air is concerned, these experiments were all negative. It does not follow that a warm, dry air is not more favorable than any other to the increase and growth of the insect, nor that the universal belief of florists that it is more likely to appear in such an atmosphere and to commit greater ravages is not true. The fact, already mentioned, that on the Pacific coast and elsewhere, in regions which have a long, dry, warm season, the red spider is especially injurious, corroborates this belief. The above experiments do conclusively show, however, that the belief that the red spider can be materially checked, much less destroyed by the presence of a moist air, is not correct.

Water. Several years ago I recommended* the use of a strong stream of water as an excellent remedy for aphides, mealy bugs and such like insects, as these sluggish creatures, unprotected by a hard covering from the force of the spray, would be knocked off and so injured that most would not return to the plants from which they came, but perish. I still use in my own greenhouse no other means of ridding plants from these unwelcome guests, and I think it a very successful method. The same plan has, to a less degree, proved satisfactory in case of the red spider. I say to a less degree, for while I rarely find a plant infested with aphides for more than a day or two, I have found it more difficult to remove the red spider in the same way, probably because of the protecting web. Still I have been fairly successful, since only now and then a plant has refused to yield to the treatment.

Another very efficient method, where the infested plants are not too numerous, is that of washing the mites from the leaves by using a sponge. This is a tedious process if plants be many or large, but if thoroughly done and if repeated from time to time, it is very effectual. Dr. Worcester, after trying

*Rpt. Vt. Exp. Sta., 3 (1889), p. 148.

various substances, came to the conclusion that this was most satisfactory of all. Whatever application is used, it is necessary to remember that *both* sides of the leaves and the stems must be treated, for in badly infested plants the insect may be found on any part of them. It is also necessary to repeat the process, so that eggs which have not been destroyed, and therefore have hatched, may not repopulate the plant.

Soap. Except when used simply for its mechanical effect clear water is less efficient than when some of the many kinds of soap which are offered for sale are dissolved in it to form a suds. Probably any kind of suds is of some value, but all are not equally useful. Dr. Worcester tried first tar soap with fairly good results, but the eggs were not killed and no remedy which does not accomplish this can be effectual unless repeated as the eggs hatch until all larvæ perish.

Eggs hard to kill. As what Dr. Worcester says in one of his notes is equally true of any insecticide I think it worth while to quote it at some length. "I found a roseleaf with a few spiders on it and also a few eggs, three or four of each. I placed the leaf on its upper surface on a crock surrounded with water and applied the suds, in this case made with tar soap, with a camel's hair brush, wetting the whole exposed surface of the leaf. After the leaf had dried I looked to see what was the effect. All the spiders seemed dead. I kept examining them at intervals for a day or two, but they never moved. Among them was, I think, one which was fixed, undergoing one of its moults. If so, its old skin did not save it. The eggs were kept to see if they too were destroyed. If fresh laid and uninjured they would hatch in about a week. On the morning of the sixth day I found a young spider and an hour or two after two more. Three eggs were empty. Therefore, suds of the strength used will kill the red spider, but not its eggs. These must be washed off. But red spiders are often found on the upper side of the leaf. To make sure both sides and also the stem must be washed. But, if by accident, one egg is left? Let us suppose that after killing the spiders and washing off the eggs, one freshly laid egg alone is left. In about a week, the weather being warm, it will hatch. In about another week it will have undergone its changes and arrived at maturity. If it be a male nothing more will come of it. It will live its solitary life and die. If it be a female the result may be far otherwise. Being parthenogenetic, she will begin at once to lay eggs at the rate of from five to eight or ten daily, and this she will continue to do, if nothing disturbs her, for three weeks or more, but the eggs of the first two weeks will hatch males only. Possibly there may be a female among them, but of this the chance, if any, is very small. At the end of about four weeks from the use of the suds, the first of these males will become mature and from this time, after pairing, the female will begin to lay eggs, some of which at least will hatch females, but it will take the earliest of these about another fortnight to hatch and come to maturity, so from about the end of the sixth week, if the weather and all else has been favor-

able, the repopulating of the plant will begin to proceed at its usual astonishing rate. About this time also, the owner of the plant, who made perhaps, in the first weeks after the washing, a few hasty examinations and found nothing, will probably be congratulating himself on his thorough riddance of the pest, it has now been so long since he has seen any signs of its presence."

The facts so well brought out in the account just given need to be kept in mind by all who are contending with any insect foe, so far as they are of general application, as most of them are, and all of them apply to other species as well as to the red spider. It must necessarily be difficult to apply any remedy that will kill not only the red spiders, but also their eggs, which will not also seriously injure the infested plants. There are many substances, however, which effectually dispose of all except the eggs. Such remedies because of convenience of application may be on the whole best, but to do any permanent good they must be applied a second time on or about the third day to destroy such mites as have hatched since the first application, and then on the third day after that to meet further hatching. Or, in most cases, it would, I think, be sufficient to wait for the second application about a week, since those larvæ that hatch would not begin to lay eggs within six or seven days, and then make the third application in another week. Carbolic, tobacco, whale oil and other soaps, have all proved serviceable remedies when used as just indicated.

Kerosene Emulsion. A very good remedy is kerosene emulsion. This is probably the best means for destroying the insect upon out-of-door plants. Forbes* states that "in June the foliage of the larches on the grounds of University at Normal were seriously affected by the red spiders, *Tetranychus telarius, L,* some of the trees seeming likely to die. On those worst infested we tried the effect of spraying with kerosene emulsion diluted to contain two and one-half per cent. of kerosene. The insects were greatly reduced in number by a single application, but not all killed. The trees soon revived appreciably as compared with those not treated." It is to be regretted that this experiment was not carried on to more complete results, but so far as it goes it is instructive and encouraging.

Gillette† finds kerosene emulsion very efficacious in destroying the eggs as well as the adults of the clover mite, which is closely allied to the red spider, and Cordley‡ says that these mites in "all stages may be perfectly destroyed" by using emulsion diluted in fifteen parts of water. The difficulty seems to be in case of red spiders that many plants will not endure a mixture of kerosene strong enough to destroy the egg. Some will not be injured, however, and perhaps further experiment will enable us to determine a dilution of emulsion that will destroy the mites in all stages and yet not be destructive to the foliage of most plants.

*Rpt. State Entomologist Illinois, 14 (Forbes, 3), (1884), p. 117.
†Rpt. Col. Exp. Sta., 9 (1896), p. 144.
‡Bul. Ore. Exp. Sta., 45 (1897), p. 121.

Experiments by Fernald* with kerosene emulsion are of interest in this connection.

"A pailful of kerosene emulsion was prepared and each rose bush inverted and dipped into it and held there a quarter of a minute, or long enough for the emulsion to reach every insect on the bush. An examination of the bushes two days later failed to reveal a single plant louse or red spider and none appeared on them during the remainder of the season." This would be more convenient in the case of small plants that could easily be dipped than any other method if it is really as effectual as the above statement would indicate. At any rate I believe that it is a most useful remedy.

Sulphur. Another remedy which has proved very satisfactory in some cases is sulphur fumes. In one of the instances mentioned a pan of sulphur was set over a small kerosene stove in a greenhouse and boiled for over three hours and the red spiders with which the house was infested were destroyed. Much care and constant watchfulness must be exercised in the use of this remedy as when heated to the boiling point it readily takes fire and gives out fumes which are very injurious to all forms of vegetation. When sulphur is used it is necessary to repeat the fumigation at intervals of about a week until all eggs have hatched. It is quite obvious that it is easier to reach all parts of a plant by fumigation than in any other manner. Sulphur fumes are also excellent for the destruction of fungi, and in cases where both a fungicide and insecticide are needed they will probably be found best of all the remedies proposed. If, however, only the red spider is to be disposed of kerosene emulsion will be found most convenient and satisfactory.

*Bul. Mass. (Hatch) Exp. Sta., 19 (1892), p. 119.

REPORT OF THE HORTICULTURIST.

F. A. WAUGH.

Experimental work in horticulture has been but recently begun at this station, the lines of work thus far followed have been somewhat tentatively adopted, and the results reported are to be regarded as an earnest of what we may hope to see accomplished rather than as a measure of the work to be expected from an old and well equipped department. Chief attention has been given to problems affecting apple and plum culture, and some results published in bulletins 53 and 55. Other matter along similar lines will soon be ready for publication. One of the most difficult problems of plum growing has been that of pollination. This has received special attention, and a report is included herewith. Other questions of varying importance have received such attention as they seemed to demand, and as circumstances enabled us to give. The subjects covered in the present report are the following:

I. Problems in Plum Pollination.
 1. Self-sterility—The Necessity for Cross-Pollination.
 2. Natural Adaptations for Cross-Pollination.
 3. Pollination Affinities of Varieties and Species.
 4. Blossoming Seasons of Plums.

II. Classification of Plums.

III. Preliminary Report on the Artificial Use of Enzyms in Germination.

IV. The Preservation of Fruits by Vapor of Alcohol.

V. A Report on the Occurrence of the Cabbage-Root Maggot.

VI. The "Italian" or "Orchid-Flowering" Cannas.

VII. A New Grafting Machine.

I. PROBLEMS IN PLUM POLLINATION.

1. SELF-STERILITY—THE NECESSITY FOR CROSS-POLLINATION.

The necessity for cross-pollination is very positive in many varieties and species of plums, and is often a controlling factor in the production of the crop. Hitherto knowledge has been scant and fragmentary concerning this quality of self-sterility whereby certain varieties refuse to be fertilized with their own pollen. Experiments made in 1896* on a few varieties indicated very general self-sterility. This year quite extensive experiments on this point gave still more striking results. A large number of blossoms in the orchards of Mr. J. W. Kerr of Denton, Md., were carefully covered with paper sacks to protect them from foreign pollen. After the plum crop was

*Bul. Vt. Exp. Sta., 53 (August 1896.)

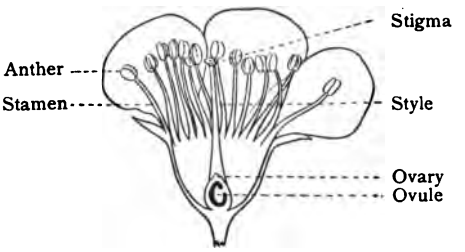


Fig. 1. Diagram of plum blossom, showing parts.

well advanced—fruit as large as peas—the sacks were removed and the records made.* Most of these records are shown in Table I at the close of the Horticulturist's report. The footings from this table are given herewith.

SUMMARY OF TABLE I.

Groups.	Varieties included.	Blossoms covered.	Fruit set.
Japanese	3	478	0
Americana	18	1709	1
Nigra	2	188	0
Miner	5	462	1
Wayland	6	856	1
Wildgoose	11	1316	0
Chicasaw	11	1419	2
Totals	56	6428	5

Five plums from 6428 blossoms can hardly be called a good crop especially when one has still to take into account loss from curculio, hail, wind, fruit-rot, and the "June drop." These experiments were made under the most favorable circumstances, every detail of the work being in my own hands, and the results are so positive and uniform that they force us to the following conclusions:

1. For all practical purposes *all classes and varieties of native plums may be regarded as absolutely self-sterile.* Exceptional varieties may be self-fertile, but they are rare. It is possible also that in other seasons or other localities self-sterility would not be so marked as in this year's work at Denton.

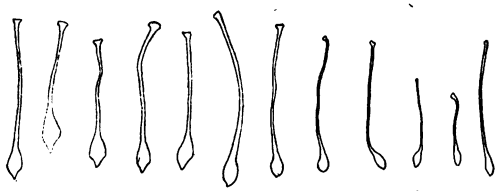
2. The Japanese plums are sometimes quite self-sterile. Satsuma appears to be always so, and cross-pollination is doubtless beneficial to nearly all varieties.

(NOTE.—No opportunity for similar experiments upon varieties of the Domestica group was found. Information collected from many reliable

*Mr. Kerr went over the whole of the work and verified every record. We are under lasting obligations to him for the freedom of his large plum orchard, and still more for the great assistance which he has personally given in the work.

sources, however, indicates commoner self-fertility in this group. The question, as it affects the Domestica group, may be regarded as an open one.)

2. NATURAL ADAPTATIONS FOR CROSS-POLLINATION.



a *b* *c* *d* *e* *f* *g* *h* *i* *j* *k* *l*

Fig. 2. Normal Plum Pistils. *a*, Lombard; *b*, Goliath; *c*, Yellow Egg; *d*, Purple Damson; *e*, Coe's Golden Drop; *f*, Improved Green Gage; *g*, Moore's Arctic; *h*, *Prunus americana; i*, *P. americana nigra; j*, Wyant; *k*, Moreman; *l*, Weaver.

This subject is discussed at length in bulletin 53, p. 50. Without repeating too much of what is said there, it will be worth while to state that plum blossoms frequently vary from their normal form (Figs. 1. and 2.); that these variations are mostly of three or four definite kinds; and that each abnormal form makes self-pollination more difficult and sometimes makes cross-pollination easier. The abnormalities which we have found to occur most frequently are:



Fig. 3. Blossoms of *Prunus americana*, showing proterogyny.

1. Defective or absent pistils, making the blossom incapable of fruit bearing.

2. Proterogyny, in which the pistil matures before the pollen and is usually thrust outside the unopened bud where it may receive pollen from another source. (See Fig. 3).

3. Long styles. This form places the stigma in such a position that pollen from the same blossom lodges upon it only with difficulty. (See Fig. 4. These blossoms also lack petals).

How Frequent are these Abnormalities?—In the last two years very large numbers of blossoms of plums and related species have been examined in field and laboratory. A tabulation of some of the laboratory notes, very much condensed, is given in Table II at the close of the Horticulturist's report. From this we take the following figures showing the average deficiency of pistils in several groups:

SUMMARY OF TABLE II. DEFECTIVE PISTILS.

Domestica group	4.3	per cent.	defective.
Japanese "	11.2	"	"
Americana "	21.2	"	"
Nigra "	17.0	"	"
Miner "	1.9	"	"
Wayland "	10.5	"	"
Wildgoose "	19.8	"	"
Chicasaw "	10.5	"	"
Hybrids "	18.1	"	"



Fig. 4. Blossoms of *Prunus americana*, with long styles and without petals.

These averages indicate fairly constant differences between the groups represented. They show that defective pistils are quite common. Long styled forms are frequently found, and proterogynous forms were surprisingly numerous this year. Dozens of varieties in which this character was very marked were noted in the orchard at Denton.

What is the Significance of these Abnormalities?—The figures given in Table II and summarized above show quite considerable differences between different groups, and these differences seem to indicate with tolerable accuracy the relative sexual delicacy of the several groups. By reference to Table II it will be noted that certain varieties are remarkably deficient and that not a few samples showed a full 100 per cent. of defective blossoms. The significance for fruitage of such a condition is entirely obvious. Such trees bear little or nothing. But it may well be doubted whether a smaller percentage (say 50 per cent or below) of defective pistils seriously jeopardizes the crop, *directly*. Plum trees, like apple trees, usually bear several times as many blossoms as can possibly come to mature fruitage. But our observations, especially those carefully made in the field, lead us to the belief that even a moderate number of defective pistils in the blossoms of any tree or variety indicates a general weakness in pollination and fruit-bearing which may be a serious factor after making allowances for the usual reduction of fruit by failure to set, curculio, "June drop," etc.

The long styled and the proterogynous forms do not seem to be so intimately associated with general sexual weakness (affecting productiveness) as are the defective pistils just considered. But they indicate even more plainly the attitude of the plant toward self-pollination; and in many cases they are unquestionably effective aids to cross-pollination.

What Causes Influence these Abnormalities?—This is the question which has usually seemed of first importance to those who have noted various cases of defective pistils. The commonest suggestion has been that defective pistils were chargeable to extremes of weather, usually severe winter cold. Data tending to refute this theory were given in our bulletin 53, p. 54. This year, with very much more material for study, we have been fully confirmed in the opinion that winter cold has very little or no influence in the matter of defective pistils. The various effective conditions and causes seem to be the following:

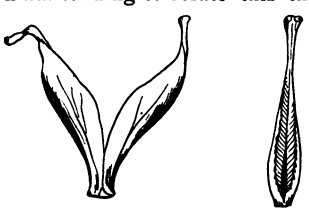


Fig. 5. Abortive (foliaceous) pistils of *Prunus cerasus fl. pl.* from doubling of the flower.

1. Physiological character of plant, variety or species. Thus defective pistils are characteristic of *Prunus americana*, while strong, vigorous pistils are characteristic of *P. domestica*. Forest Garden, Rollingstone and Wolf are usually considerably defective though Rockford and Hawkeye of the same group are much less so.

2. Age of tree. Young trees frequently blossom, but do not bear. The blossoms may be largely or wholly defective. (Exemplified in Bul. 53, p. 53.)

3. Health of tree. A badly diseased or dying tree usually shows seriously defective pistils. This may be noted on trees severely attacked by black knot, or by the brown rot (*Monilia fructigena*) which is yet more potent in this direction. Here are two sample records made on adjacent trees:

Burbank, tree healthy	2 per cent. defective.
Burbank, tree dying (of brown rot fungus)	58 " "

4. Storage of food materials. Repeated observations have shown that buds so situated upon a branch as to command a relatively large storage of food give, as a rule, large blossoms, large ovaries and perfect pistils; while other buds less favorably situated on the same twigs develop sickly looking blossoms with pistils weak or wanting. Any condition of an entire tree which prevents the normal storage of food materials in buds and branches is likely to show in defective pistils at the next blossoming season. Mr. L. M. Macomber's tree of "Wolf Seedling No. 4" at North Ferrisburgh, Vt., bore much too large a crop in 1896. All the strength of the tree was exhausted in bringing the fruit to maturity and no storage was possible. In 1897 it had not a perfect blossom. In fact most of the variations in defective pistils may, according to our observations, be due directly or indirectly to differences in food storage.

3. POLLINATION AFFINITIES OF VARIETIES AND SPECIES.

A desirable plum proves to be self sterile; what other variety can be depended on to pollinate it to the best advantage? Evidently this is a question of prime importance, and one upon which reliable generalizations would be especially acceptable. Unfortunately, such generalizations cannot yet be safely made. The pomologists, and especially the fraternity of "plum cranks," are accumulating a mass of empiricisms which are sometimes useful and sometimes deceitful, but which will help, at a future day, in the derivation of more general truths. A number of crossing experiments were made this year at Denton designed to throw light on this question; others were made at North Ferrisburgh, Vt., in 1896; but the results of these experiments are too meager and contradictory to justify further discussion of them at present.

Meanwhile some of the more definite practical observations may be of service. Wildgoose, which has long been known to be self-sterile, may be safely pollinated by Newman, (a Chicasaw) Milton, Sophie, Poole's Pride, Robinson, Smiley and in some localities by Miner.* Marianna may be pollinated by DeCaradeuc, Early Red, or Caddo Chief. Miner may probably be pollinated by Wildgoose, Smiley, and Whitaker. For pollinating Moreman,

*Moreman, which has been widely recommended for the pollination of Wildgoose, is utterly worthless in most localities because it blossoms too late. See the plum blossoming charts on pages 94-98.

Miner is effective where it blossoms late enough, while it may be fairly expected that most members of the Wayland group, which blossom nearly all together, will also prove satisfactory. But our knowledge on this subject is mostly too uncertain to be worthy of record. Any further specific statements would be chiefly guesswork, and quite apt to mislead the plum orchardist instead of helping him.

4. BLOSSOMING SEASONS OF PLUMS.

It is obvious that, in order that one variety may pollinate another, the two must be in blossom at the same time. In the southern states the plum blossom season covers a full month, while the duration of the blossoms of any one variety is seldom more than five or six days, often only two or three. The chances are thus very great that any two varieties selected at random will miss each other in blooming season and thus prove mutually useless for purposes of cross-pollination.

Commencing with a plum blossoming season of four to five weeks in the gulf states the season shortens as it passes northward. In the latitude of Washington the season extends over three to four weeks, while at Burlington, Vt., the season is reduced to one to two weeks. The average length of the plum blossom season here is about nine or ten days, with an average duration of two to three days for each variety.

The following comparison of blossoming periods for well known varieties at Denison, Texas, and at Ottawa, Ontario, is arranged from notes furnished by Mr. T. V. Munson and Mr. John Craig. It will enable the reader to see at a glance the extremes of the blossoming seasons.

COMPARISON OF BLOSSOMING PERIODS.

VARIETIES.	1896.		1897.	
	Texas.	Ontario.	Texas.	Ontario.
De Caradeuc	Mar. 20	May 5	Mar. 7	May 12
Burbank	" 18	" 9	" 8	" 15
Abundance	" 20	Apr. 28	" 9	" 10
Marianna	" 20	May 10	" 9	" 9
Wildgoose	" 26	" 30	" 17	" 18
Chas. Downing		" 22	" 20	June 1
Milton	Mar. 26	" 13	" 21	May 28
Miner	Apr. 1	" 12	" 22	" 20

Careful attention has been given to the problem of blossoming seasons. Records for three years from Mr. Kerr's large orchards, and a great mass of valuable blossoming notes from other orchards all over North America were available.* Taking the notes from Mr. Kerr's orchard as the basis—they

*These data included blossoming records of leading varieties for five years at Geneva, N. Y.; a long comparison for two years at Denison, Tex.; complete notes from South Haven, Mich.; and more or less complete notes from Lake City, Fla.; Auburn, Ala.; Starkville, Miss.; College Station, Tex.; Phoenix, Ariz.; Santa Rosa, Cal.; Pullman, Wash.; Logan, Utah; St. Louis, Mo.; Manhattan, Kan.; Lincoln, Neb.; Minnesota City, Minn.; Madison, Wis.; State College, Penn.; Amherst, Mass; Ororo, Me.; Ottawa, Ont.; Wolfville, N. S.; and several other points.

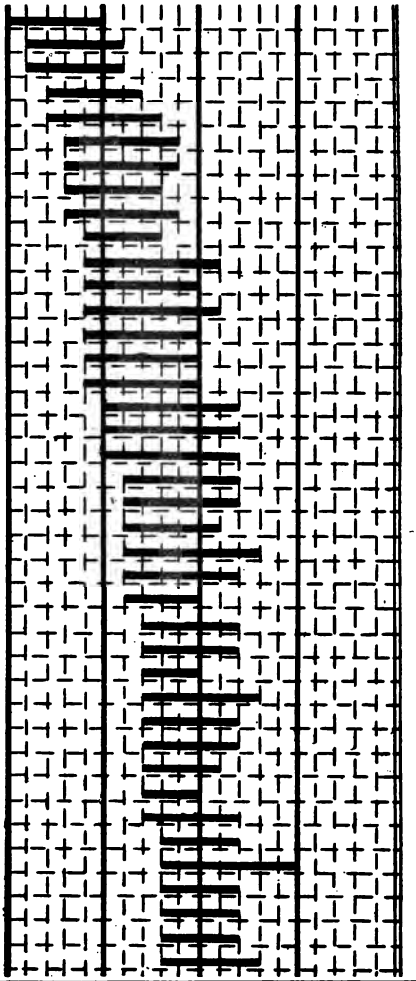
being the most complete—and correcting them by comparisons with the other notes at hand, we have arranged the following chart of relative blossoming periods for a considerable series of varieties. The chart represents actually the average blossoming season in the latitude of Denton, Md., (which is about that of Washington) but the relative positions of the varieties would not be greatly changed for any other latitude. Going south from Maryland one would need to interpret these data with increasing caution ; going north one might expect varieties to overlap somewhat further than here shown.

Before proceeding to a study of the blossom charts some further discussion of the problems involved seems necessary. Do given varieties always blossom in the same order in the same and in different localities ? No, not precisely. Considerable divergencies may *sometimes* be observed when comparing the order of blossoming in one locality with that in another, or even when comparing two seasons in the same locality. But these divergencies are not the rule, and the safety of the average is not seriously affected by them. The same discrepancies occur in the matter of proterogyny and proterandry. Varieties may show proterogyny in one locality and proterandry in another ; or may be proterandrous one year and proterogynous the next in the same locality. The explanation of both classes of variations is the same and is involved in the problem of the socalled climato-physiological constant. This problem, namely the scientific explanation of these variations, has also received close attention this year. We had hoped to publish in this connection a full discussion of this question ; but, being unable to do so, have postponed it to a more convenient opportunity.

PLUM BLOSSOM CHART.

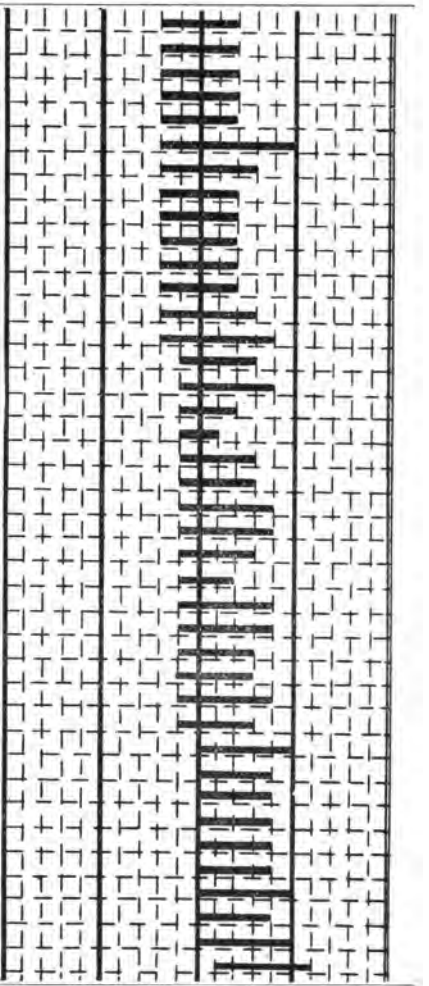
Showing Average Plum Blossoming Seasons in the Latitude of Denton, Md.

VARIETY.	CLASS.
Burbank	Japanese
Abundance	do
Satsuma	do
DeCaradeuc	Hybrid
Georgeson	Japanese
Engre	do
Marianna	Hybrid
Ogon	Japanese
Chase	do
Brill	Hybrid ?
Chabot	Japanese
Kelsey	do
Ogeechee	Chicasaw
Shiro Smomo	Japanese
Strawberry	Watsoni
Uchi Beni	Japanese
Maru	do
Wazata	Nigra
Yosebe	Japanese
Caddo Chief	Chicasaw
Early Red	do
Emerson	do
Itasca	Nigra
Kerr	Japanese
Munson	Chicasaw
Beaty	do
Clark	Wildgoose
Clifford	do
Colletta	Chicasaw
Deepcreek	Americana
Drouth King	do
El Paso	Chicasaw
Hattie	Myrobalan
Yellow Sweet	Americana
Arkansas Lombard	Chicasaw
Cheney	Nigra
Desoto	Americana
Harrison	do
Heaton	do
Hiawatha	do



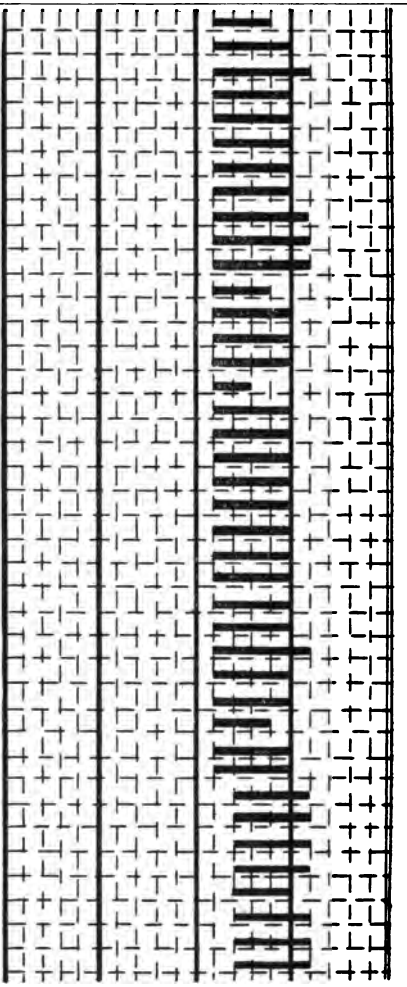
PLUM BLOSSOM CHART, CONTINUED.

VARIETY.	CLASS.	9th Apr. 14th. 19th. 24th. 29th.
Hogg's No. 2	Hybrid	
Hughes	Chicasaw	
Jefferson	Domestica	
Lombard	do	
Milton	Wildgoose	
Newman	Chicasaw	
Ocheeda	Americana	
Richland	Domestica	
Rollingstone	Americana	
Spaulding	Domestica	
Wilder	Miner	
Wildgoose	Wildgoose	
Willard	Japanese	
Yellow Panhandle	Watsoni	
African	Chicasaw	
Cherokee	Americana	
Freeman's Favorite	Wildgoose	
Gaylord	Americana	
Hilltop	do	
Louisa	do	
Miner	Miner	
Minnetonka	Americana	
Ohio Prolific	Wildgoose	
Osage	do	
Smiley	do	
Speer	Americana	
Texas Belle	Wildgoose	
Van Buren	Americana	
Whitaker	Wildgoose	
Yellow Transparent	Chicasaw	
Comfort	Americana	
Cottrell	do	
Cumberland	Wayland	
Kickapoo	Americana	
Lone Star	Chicasaw	
Lord's Seedling	Americana	
Rockford	do	
Roulette	Wildgoose	
Schley	do	
Champion	Americana	



PLUM BLOSSOM CHART, CONTINUED.

VARIETY.	CLASS.	9th Apr. 14th. 19th. 24th. 29th.
Chas. Downing....	Wildgoose	
Clara.....	Americana?	
Cluck....	Chicasaw	
Crescent City.....	Miner	
Columbia.....	Wayland	
Dr. Tyler's Sugar D'p	Domestica	
Gordon....	Americana	
Hammer.....	do	
Hawkeye.....	do	
Idall.....	Miner	
Indian Chief.....	Wildgoose	
Indiana Red.....	Miner	
Jewell.....	Wildgoose	
Kampeska.....	Americana	
Kopp.....	do	
LeDuc..	do	
Maquoketa.....	Miner	
Muncy.....	Americana	
Nelly..... ...	do	
North Carolina....	do	
No. 0. (Kerr).....	do	
No. 6. (Kerr).....	do	
No. 20. (Kerr)....	do	
Old Gold.....	do	
Parsons.....	Miner	
Pottawattomie....	Chicasaw	
Prairie Flower.....	Miner	
Purple Yosemite....	Americana	
Sophie..... ..	Wildgoose	
Sucker State.....	Wayland	
Weaver....	Americana	
Wooten.....	Wildgoose	
California.....	Americana	
Coe's Golden Drop.	Domestica	
Colorado Queen...	Americana	
Dakota....	do	
Forest Rose.....	Miner	
German Prune.....	Domestica	
Hanson.....	Americana	
Honey.....	do	

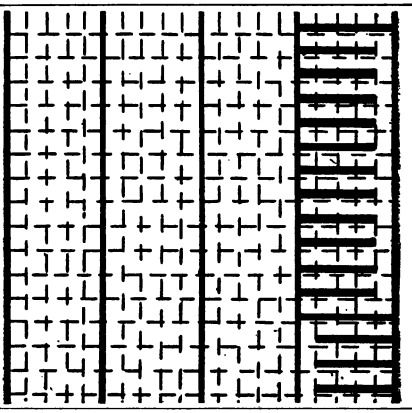


PLUM BLOSSOM CHART, CONTINUED.

VARIETY.	CLASS.	9th Apr. 14th. 19th. 24th. 29th.
Iris	Miner	
Jones' Late	Americana	
Knudson's Peach	do	
Macedonia	Wildgoose	
Mankato	Americana	
Maryland	Hybrid	
Missouri Apricot	Wayland	
Moore's Arctic	Domestica	
Moreman	Wayland	
Noyes	Miner	
Piram	Chicasaw	
Poole's Pride	Wildgoose	
Reine Claude	Domestica	
Gen. Hand	do	
Shropshire Damson	do	
Stoddard	Americana	
Surprise	do	
Williams	Nigra	
Williams' No. 17	Americana	
Wolf	do	
Forest Garden	do	
Red Panhandle	Watsoni	
Smith	Americana	
Utah Hybrid	Hybrid	
Wayland	Wayland	
Worldbeater	do	
Wyant	Americana	
American Eagle	do	
Garfield	Wayland	
Illinois Ironclad	Americana	
Irene	do	
Kanawha	Wayland	
Leptune	do	
Marion	Americana	
Blackhawk	do	
Rachel	Miner	
Reed	Wayland	
Choptank	Wildgoose	
Esther	Miner	
Galena	Americana	

PLUM BLOSSOM CHART, CONCLUDED.

VARIETY.	CLASS.	9th Apr. 14th. 19th. 24th. 29th.
Golden Beauty....	Wayland	
Heideman's 88....	Americana	
Heideman's Black..	do	
Heideman's Red...	do	
Heideman's Yellow.	do	
Newton Egg.... .	do	
Pendent.....	do	
Reche..... ...	do	
William's No. 0....	do	
Winnebago.....	do	
Wood	do	
Prunus maritima..	Maritima	
Holt..	Americana	
Joe Hooker... ..	do	
Pfeffer's Premium..	do	
Smith's Red... ..	do	



II. CLASSIFICATION OF PLUMS.

The studies reported here were undertaken primarily to throw light on problems in pollination. But the classification of our multitudinous varieties of plums, especially those of native parentage, is a matter of the gravest interest to pomology in general. The rapid introduction and constant interbreeding of varieties makes it almost impossible, except for the specialist, to know anything about them. The first and greatest step in this sort of knowledge is classification. Science is classified knowledge; and we may be said to have a scientific pomology only in so far as we have our knowledge thoroughly classified. Moreover, there are certain well marked groups of plums; and when the fruit grower has once learned these he does not need to investigate each new variety if he may only be assured of its pomological relationships.

Our pomological classifications of plums are usually and properly based on botanical classifications; and many of the critical questions thus really become questions of botany. This has been an advantage in so far as it has enabled us to secure the help of trained botanists upon our horticultural problems. It has been a disadvantage in some cases when it has led practical pomologists of shrewd judgment to feel that their own observations were not to be relied on because not based on the book-science of botany. The truth is that practical experience with the varieties in question and critical botanical knowledge are both required to settle these matters of plum classification. We must all work together and have patience.

It very much needs to be said, further, that botanical science and botanists are not infallible. If they were, we might all see things alike and all agree.

But botanical classification itself is a matter of judgment, and as judgments vary, botanical decisions vary. It is no impeachment of plum botanists that they disagree. Nor is it a mark of incapacity that one should change his mind. One who does not change his mind whenever the evidence warrants is prejudiced and thoroughly unsafe.

The following classification is presented, then, not in the expectation that it will satisfy everybody, nor in the hope of settling permanently all the troublesome questions in this branch of pomology, but to express the best judgment of two students (Mr. J. W. Kerr and the writer) regarding the relationships of our cultivated plums. It will not be out of place to say that Mr. Kerr has the best practical acquaintance with the largest number of varieties of any man in the world. The results of his many years of observation have been drawn upon at all times in the progress of this work. The matters of botany have been mainly in the hands of the writer, with much-appreciated help from the best specialists in the country.

The common varieties of plums now in cultivation in America may be best understood, we believe, when arranged in the following principal groups:

DOMESTICA GROUP.	The European garden plums and their seedlings.	*Prunus domestica.*
JAPANESE GROUP.	The Japanese plums.	*Prunus triflora.*
AMERICANA GROUP.	The western American wild plums and their cultivated descendants.	*Prunus americana.*
NIGRA GROUP.	Varieties mostly derived from the wild plums of northeastern North America.	*Prunus americana nigra.*
MINER GROUP.	Varieties resembling Miner, passing into the Americanas on one side, and into the Wildgoose group on the other.	*Prunus hortulana.* (Of hybrid origin)
WAYLAND GROUP.	Varieties resembling Wayland.	
WILDGOOSE GROUP.	Varieties resembling Wildgoose, but passing indistinguishably into the next.	
CHICASAW GROUP.	The Chicasaw plums.	*Prunus angustifolia*
MARIANNA GROUP.	The Marianna and others.	Probably hybrids.

Other groups of minor importance at present are *Prunus maritima*, *P. watsoni*, *P. subcordata*, *P. simonii* and *P. cerasifera* (the Myrobalan plum.) Other species from which we may expect to see important introductions at any time are *Prunus rivularis*, *P. glandulosa*, *P. gracilis* and *P. umbellata*.

THE DOMESTICA GROUP.

These plums are known everywhere, and are always easily recognized. All the old fashioned garden plums belong to this group. The varieties

named below are those with which our own work has had most to do. The list does not constitute an inventory of varieties grown in America. The following are, however, fairly representative of this group:

Bradshaw	Lincoln
Clyman	Moore's Arctic
Coe's Golden Drop	Pond's Seedling
Communia	Quackenboss
Early Red	Reine Claude
Fellenberg Prune	Richland
Gen. Hand	Shipper's Pride
German Prune	Shropshire Damson
Green Gage	Spaulding
Imperial Gage	Tatge
Jefferson	Washington
Lombard	White Nicholas

Yellow Egg.

THE JAPANESE GROUP.

The Japanese plums are now well known in America. Large numbers of varieties have been recently introduced. The following list comprises those most commonly grown*:

Abundance	Kelsey
Berckmans	Longfruit
Bailey	Maru
Berger	Normand
Burbank	Ogon
Chabot	Red June
Chase (Yellow Japan)	Satsuma
Ergre	Uchi Beni
Georgeson	Willard
Hale	Wickson
Kerr	Yosebe

THE AMERICANA GROUP.

The many varieties of this important group are characterized by strong-growing, medium to large trees with dark colored bark, by ovate leaves coarsely and sharply serrate, rough and usually without glands, by flowers usually white, and by tough, bitter skins upon the fruit. The species is found wild all through central North America, from near Hudson's Bay to the Mexican border. Eastward it merges into the next form. The varieties which we think should be referred to this group are the following:

*For a full account of varieties of Japanese plums, see Bailey, Bul. Cornell Exp. Sta., 106 (Jan. 1896.)

Aitkin
American Eagle
Apricot
Bender
Bixby
Blackhawk
Brittlewood No. 1
Brittlewood No. 2
California
Carver
Champion
Cherokee
Colorado Queen
Comfort
Comptine
Cottrell
Dahlgreen
Deepcreek
Des Moines
De Soto
Dr. Dennis
Dunlap's No. 1
Etta
Forest Garden
Galena
Gale's No. 3
Gaylord
Gold
Grayson
Haag
Hammer
Hanson
Hartwick
Hawkeye
Heaton
Heideman's 88
Hiawatha
Hilltop
Hovey
Hunt
Ida
Illinois Ironclad
Iona
Iowa
Iowa Beauty
Irene
Isaac
Ivason
Joe Hooker
Jones
Jones' Late
Kampeska
Kickapoo
Kieth
Knudson's Peach
Kopp
Labert's Red
Large Red Sweet
Le Duc
Le Duc Vermillion
Leonard
Lockey
Louisa
Manitoba
Manitoba No. 1
Manitoba No. 2
Manitoba No. 4
Manitoba No. 5
Mankato
Marcus
Marion
Meyer
Miller
Minnetonka
Monon
Moon
Muncy
Nelly
Newton Egg
New Ulm
North Carolina
North Star
Ocheeda
Old Gold
Pearl
Penning's Free
Pfeffer's Premium
Purple Yosemite

Quaker	Stoddard
Quaker Beauty	Tecumseh
Rebecca	The Cook's Choice
Reche	Van Buren (var. *mollis*.)
Red Cloud	Van Deman
Redhorse	Waraju
Rockford	Weaver
Rocky Mountain Dwarf	Wildrose
Rollingstone	Williams' No. 20
Rollingstone Late	Winnebago
Schoenthal	Wolf
Silas Wilson	Wood
Sloe	Wyant
Smith	Yellow Sweet
Speer	Yellow Yosemite

THE NIGRA GROUP.

Such botanists as Gray and Bailey have classified the wild plums of the east and those of the west all together, applying Marshall's name, *Prunus americana*. Others, as Sargent, have thought best to revive Aiton's name of *Prunus nigra* for the northeastern forms. One cannot help being struck at first sight by the differences between the common western *Prunus americana* and the eastern wild plum and is likely then to sympathize with the botanical classification which separates the two. But when one comes to a more extensive examination of all the intermediate forms, and *especially when one undertakes a study of the cultivated varieties* he must be increasingly convinced that *the two groups are inseparable*. There are several varieties in cultivation which show the most puzzling combinations of Nigra and Americana characters. They may be put into one group or the other on the arbitrary judgment of the pomologist; but they are a constant stumblingblock to the botanist who likes to make species with high fences between them. These difficulties can best be met by recognizing the Nigra group and its close affinity with the Americana group; and to this end the present writer has proposed to separate the eastern forms under the botanical designation of *Prunus americana nigra*.* The varieties which seem to belong to this group rather than to the former are the following:

August	Penning's Peach
Cheney	Seper's Peach ?
Harrison's Peach	Smith's Red
Itasca	Wazata
Oatey	Williams

**Prunus americana nigra*. F. A. Waugh, Bul. Vt. Exp. Sta., 53 (August, 1896), p. 58.
Prunus nigra Aiton, Hort Kew. ed. 1., II., p. 165.
Prunus mollis Torrey, Fl. U. S., I., p. 470.
Prunus americana Torrey & Gray, Fl. N. A., I., p. 407, in part.

THE MINER GROUP.

This group was characterized by Bailey* as differing from the Wildgoose plum "by the dull and comparatively thick leaves, by a late, very firm fruit and by a more or less smooth and Americana-like stone." It has always been regarded as intermediate between the Wildgoose and the Americana types; and now that a hybrid origin is supposed for all the Hortulanas we may conceive either that the Miner type arises from a secondary hybridization between Wildgoose and Americana, or that it includes primary hybrids in which the Americana influence has preponderated. We have assigned the following varieties to this group:

Clinton	Maquoketa
Crescent City	Miner
Esther	Nebraska
Forest Rose	Noyes
Idall	Prairie Flower
Indiana Red	Rachael
Iris	Wier's Large Red

Wilder

THE WAYLAND GROUP.

This is the most distinct subdivision of the Hortulana class. The varieties are much more easily separated from those of other groups than are the varieties of the Miner or Wildgoose groups. Nevertheless these varieties, strangely enough, have hitherto not been put by themselves, but have been variously included in the Miner and Wildgoose groups. T. V. Munson has recently called attention to the distinctness of Golden Beauty and Wayland, and has been able, as he thinks, "to prove certainly their identity with *Prunus rivularis* Scheele, of western Texas." The group is certainly an anomalous one, and may prove, when we understand it better, to belong outside the Hortulana class of hybrids; but the most careful study does not yet satisfy me that these varieties are derived from *Prunus rivularis*. Scheele's description† is not very precise, and our knowledge of the species is still so very meagre as to forbid any positive disposition of this question. These varieties have also been referred to *Prunus glandulosa* Torr. & Gray, an assignment which is evidently wrong.

*Bul. Cornell Exp. Sta., 38 (1892), p. 23.

†As *Prunus rivularis* seems likely to prove a factor in American plum botany hereafter, the following translation of Scheele's original description from Linnæa 21, 594, may prove of service:

PRUNUS RIVULARIS Scheele. Stem 3-6 divided; branches angular, glabrous, shining, cinerous, roughened, warts somewhat crowded; petioles glandular, canaliculate, puberulous; leaves ovate-oblong, acuminate, unequally serrate, glandular at the base, glabrous above, pubescent below; serratures callous, appressed; umbels lateral, sessile, usually 2-flowered; flower stalks without leaves; peduncles glabrous, elongated, subglandular, equaling the petioles; drupe red, globose, glabrous, shining, sour.

Growing together in clumps on the banks of streams, seldom but sometimes growing in thickets on hills. Stem 3-6 feet high. Fruit spherical, clear red, pleasant sub-acid, from the size of a cherry to that of a Myrobalan plum, ½-1 inch in diameter. The blossoms are seldom borne singly.

The group is characterized by straight, slender, dark colored twigs, very large, luxuriant foliage, broad leaves, which are often pubescent on the larger veins beneath, and which have 2 to 6 glands on the petioles; axillary buds often triple; blossoms and fruit very late, mostly after Miner; fruit spherical or nearly so, red or yellow with many small dots, thin skinned and of fine quality. The varieties which belong here are as follows:

Columbia	Missouri Apricot
Crimson Beauty	Moreman
Cumberland	Nimon
Garfield	Reed
Golden Beauty	Sucker State
Kanawha	Wayland
Leptune	Worldbeater

THE WILDGOOSE GROUP.

From the pomological standpoint this is probably the most important group of native plums. They are characterized by "strong, wide-spreading trees, with smooth, straight twigs, and a peach-like habit; leaves narrow-ovate or ovate-lanceolate, thin and firm, more or less peach-like;" fruit bright colored, usually red, with thin skin, with a roughened, small, pointed stone. In 1892* Bailey described the species *Prunus hortulana* to include these varieties, and those of the Wayland and Miner groups. More recently, however, the same author has decided that this is "a mongrel group, undoubtedly hybrids" of *Prunus americana* and *P. angustifolia.*† This latter view‡ of the "Hortulanas," as they are now often called, will be more acceptable to pomologists, for it enables us to understand the confusing variations among the varieties under discussion. These different varieties must have had several independent hybrid origins; and it is thus quite intelligible that certain ones should be almost indistinguishable from the Chicasaws, and that others should be much like the Americanas. It clears matters still further by enabling us to see how such distinct types as the Miner and the Wayland could have had a similar origin. There are really four fairly distinct pomological groups comprised in the great Hortulana class. The Wildgoose is the leading group. The Miner group has always been placed separately. The Wayland group is here separated and characterized for the first time, but is the best marked group of all. There is still another group comprising such varieties as Clifford, Schley and Wooten, which lie midway between Wildgoose and the pure Chicasaw plums. These varieties grade so closely into each other that it is quite impossible to divide them by any line except a purely arbitrary one. In the following list of varieties which we prefer to

*Garden & Forest, 5 (1892), p. 90.

†Bul. Cornell Exp. Sta., 131 (March, 1897), p. 170. Bot. Gaz., Dec. 1896, p. 461.

‡For further discussion of this question see "The New View of the Hortulana Plums," F. A. Waugh, Garden & Forest 10 (1897).

put in the Wildgoose group, we have marked with an asterisk (*) those which approach most closely the borders of the Chicasaw group:

Chas. Downing
Choptank
*Clark
*Clifford
Davis
*Drouth King
Dunlap's No. 2
*El Paso
Freeman's Favorite
*Hollister
Indian Chief
James Vick
*Jewell
Kroh
*Macedonia
*Ohio Prolific
*Osage
*Poole's Pride
Roulette
*Schley
Smiley
Sophie
*Thousand-to-One
*Texas Belle
Whitaker
Wildgoose
*Wooten

THE CHICASAW GROUP.

The Chicasaw plums are native to the southern states. All the cultivated varieties thrive as far north as Washington, some varieties grow well in the latitude of New York, and some of the healthiest and most productive trees I have ever seen in Vermont were Mr. Macomber's Pottawattomies (Chicasaws) at North Ferrisburgh. They are characterized by slender zigzag twigs with small peach-like trough-shaped leaves, and by very thin-skinned juicy fruit which is usually red. It is sometimes difficult to separate these from the Wildgoose group, and varieties of *Prunus watsoni* are especially apt to be mistaken for Chicasaws. The two names *Prunus angustifolia* and *Prunus chicasa*, have been in common use by American botanists for this species; but the former has the preference of correctness. The following varieties seem to belong here:

African
Arkansas Lombard
Beaty
Caddo Chief
Cluck
Colleta
Early Red
Emerson
Emerson's Yellow
Hughes
Jennie Lucas
Lonestar
Mason
Munson
Newman
Ogeechee
Piram
Pottawattomie
Robinson
Yellow Transparent

THE MARIANNA GROUP.

The varieties in this group are very closely related to the common Myrobalan plum (*Prunus cerasifera*) and may be merely vagrant seedlings from that species. They appear, however, to have had some admixture from other

*The asterisk marks those varieties which depart from the true Wildgoose type toward the Chicasaws. Some of these are very difficult of classification.

species, possibly from Wildgoose or Chicasaw varieties. They are usually spoken of by themselves, and are here presented separately because this gives the best understanding of them. The varieties are :

De Caradeuc	Hattie
Early Cherry	Brill
Marianna	Hogg's No. 2

MISCELLANEOUS VARIETIES.

The following miscellaneous varieties, some of them exceedingly interesting, have come under study during this year's work. We indicate below their several relationships as well as they can now be explained.

Basset's American, *Prunus maritima.*
Bursoto, Burbank (*P. triflora*) × DeSoto (*P. americana.*)
Excelsior, Kelsey (*P. triflora*) × Chicasaw (variety unknown.)
Maryland, Seedling of Utah Hybrid, the latter probably a hybrid of *Prunus watsoni* × *P. besseyi.*
Purple Panhandle, *Prunus watsoni.*
Red Panhandle, *Prunus watsoni.*
Strawberry, *Prunus watsoni.*
Yellow Panhandle, *Prunus watsoni.*

III. PRELIMINARY REPORT ON THE ARTIFICIAL USE OF ENZYMS IN GERMINATION.

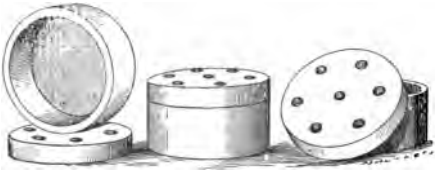


Fig. 6. Germination cups.

When an animal digests food much of the work is accomplished through the action of certain enzyms, the so-called unorganized ferments. Thus pepsin aids digestion by changing insoluble albuminoids to soluble peptones. Diastase, trypsin, ptyalin, and the pancreatic juices have similar functions. Botanists now agree in the belief that in certain cases similar enzyms (unorganized ferments) stand in the same relation to various processes of plant digestion. A seed consists of a small germ with a comparatively large storage of food materials (mostly starch) on which the young plant may feed until it becomes established and able to forage for itself. It is evidently of great importance during germination that these stored materials shall be properly digested, and made rapidly available for the young plantlet. This is probably accomplished largely through the action of enzyms. It is possible, then, that in some cases in which seeds fail to germinate strongly the explanation may lie in the lack or the inefficiency of the enzyms usually present in good seeds. In such cases it seems reasonably possible that the artificial application of the lacking ferments might accomplish the digestion of mate-

rials stored in the seed, and so assist germination. Pepsin is taken by human dyspeptics to aid digestion. Why not expect good results from a similar treatment of old seeds of apparently low viability? This question has been approached the past year through a large number of preliminary experiments made upon seeds of several sorts and ages, and with various enzyms or enzym preparations. Similar experiments were made with dormant bulbs, tubers and cuttings, with conflicting results.

The terms "enzyms," "unorganized ferments," "soluble ferments," are understood to apply to a number of highly complex organic bodies of an albuminoid character, which possess the power of bringing about chemical changes on a scale altogether out of proportion to their own mass. Their mode of action is not fully understood. They are nevertheless extremely common both in animal and vegetable economy, and their action is of the utmost importance.

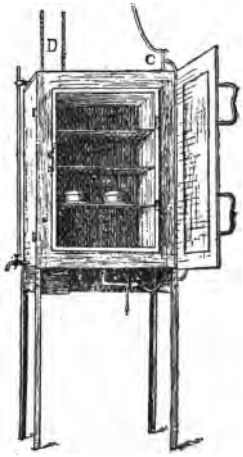


Fig. 7. Water bath used as a germination chamber.

PREPARATION OF ENZYMS TESTED.

The principal ferment agents tried were as follows:*

Pepsin, "5 *per cent.*" (*c*).—This solution was made by dissolving 5 grams commercial pepsin in 100 c.c. water. Armour's soluble granular pepsin used in our experiments, when tested separately, showed an efficiency of approximately 80 per cent., which would make this actually a four per cent. solution if computed on the basis of active pepsin present.

Pepsin, "10 *per cent.*" (*d*).—Same as solution *c*, except that it contained twice the amount of pepsin.

Diastase, "5 *per cent.*" (*f*).—To make this solution 10 grams of finely ground malt was added to about 170 c.c. water. This was shaken freely for two hours and allowed to stand over night at room temperature. In the morning it was filtered, and made up to 200 c.c. The actual diastase present in such a solution is exceedingly small. A quantitive estimation is impracticable; but it was determined that, under the conditions of our experiments, 100 c.c. of this solution contained diastase enough to digest 0.2 grams starch in one hour.

Diastase, "10 *per cent.*" (*g*).—This was made exactly like solution *a*, except that it contained twice as much malt.

Diastase and Pepsin, (*each* "2½ *per cent.*") (*h*).—This solution, which has

*These solutions were prepared by Mr. C. H. Jones, assistant chemist, whose co-operation in this work has been of material assistance.

been used but a few times, was made by mixing equal quantities of solutions *c* and *f*.

Extractum Pancreatis,* (*i*).—The solution used in our experiments was composed as follows:

Extractum Pancreatis	0.65 grams.
Sodium bicarbonate	1.95 grams.
Water	100 c.c.

Extractum Pancreatis, (*m*).—The same materials used in solution *i* were combined to make a solution only half as strong, as follows:

Extractum Pancreatis	0.375 grams.
Sodium bicarbonate	1.950 grams.
Water	150 c.c.

Trypsin, (*j*).—The commercial article was used in the following proportions:

Trypsin	3.9 grams.
Sodium bicarbonate	1.3 grams.
Water	100 c.c.

Trypsin, (*n*).—Was made as follows:

Trypsin	1.95 grams.
Sodium bicarbonate	1.30 grams.
Water	100 c.c.

Enzymol, (*k*).—The commercial article and water were combined in equal proportions.

Enzymol, (*o*).—Contained one part of the commercial article to two parts of water.

Diastasic Essence of Pancreas, (*l*).—The commercial article and water were combined in equal proportions.

Diastasic Essence of Pancreas, (*p*).—Contained one part of the commercial article to two parts of water.

Check.—In all experiments a check sample of the seeds under test was soaked in water. In some cases, also, another sample was allowed to stand quite dry and untreated till all were put into the germinators under precisely equal conditions.

METHODS OF GERMINATION TESTS.

Geneva seed testers were used in a large number of our experiments; but for the most part more satisfaction was found in the use of germination cups made after the design of Kinney.† The Geneva tester was placed upon the greenhouse bench, and took its temperature from the room. The germinating cups were nested in trays containing water, and were kept in a water bath. The whole apparatus was set in the greenhouse during most of the experiments, and kept at nearly the same temperature as the room, although the water jacket made the fluctuations of temperature within much less than

*The Extractum Pancreatis, Trypsin, Enzymol, and Diastasic Essence of Pancreas, are prepared for medical use. The manufacturers, Messrs. Fairchild Bros. & Foster, of New York City, kindly donated them for our experiments.

†Bul. R. I. Exp. Sta., 35 (1895), p. 137. See, also, L. H. Bailey, Nursery Book, 3d ed., p. 14.

they were without. The water bath was fitted with a thermostat, by which the temperature could be kept exactly uniform; but after some few experiments this was not used.

The apparatus was managed to secure the most vigorous germination possible. When a series of samples showed the complete germination of the strongest seeds, the count was made and the experiment discontinued. Only those seeds were counted which gave vigorous plantlets, likely to survive in such a struggle as seedlings find in the open field. Tardy and weak germinations were not counted.

RESULTS OF EXPERIMENTS.*

Among several hundred preliminary experiments already made many have given negative results. This was to be expected. Very frequently the effect of the enzym solutions was detrimental, or even fatal to the seeds. Often the treated seeds rotted quickly. Under other conditions these deleterious effects were much mitigated, and sometimes so far overcome as to show a positive gain from the treatment. The fact that seeds were frequently damaged by all the solutions used makes the results all the more striking in those cases where positive beneficial effects were secured. It is quite evident from experiments already made that a great many empirical details are still to be worked out. The temperature at which the treatment and the germination are made is of great importance. The particular enzym or enzym combination must be separately determined for each species of seed.† The optimum strength for each solution and perhaps for each species is a delicate and important matter.

*The only experiments similar to those reported here of which we find record were made by A. Thomson, of the Royal University of Jurjew, in Dorpat, Russia. Only a very few experiments made on a small scale were reported in Gartenflora (Berlin) 45, p. 344, July, 1896. The entire series of experiments as reported is given herewith, the figures showing per cent. of germination.

RESULTS REPORTED BY A. THOMSON.

Seeds Used.	Water.	Pepsin 5%	Diastase 5%	Diastase 10 %
Barley	4.5	10	35	48
Oats	16	39	47	54
Corn	3	38	49	..
Corn	3	17	20	..
Peas	5	..	22	..
White Clover	17	18	50	..
Yellow Clover	7	12	13	..

†This statement is based on our own experiments. In this connection the investigations of Fischer are of special interest. (Emil Fischer, Einfluss der Configuration auf die Wirkung der Enzyme, Ber. deut. chem. Ges., 27 (1894), pp. 2985 and 3479. See also articles by same author in same reports as follows: 27 (1894), p. 2036; 28 (1895), pp. 984 and 1429. Cf. Winthrop E. Stone, U. S. Dept. Agr., Office Exp. Sta., Bul. 34, p. 30.) Fischer concludes (l. c. 27, p. 2992) that the enzyms exercise a direct choice among the materials on which they might be expected to act, and that this choice depends on the molecular configuration of the substance acted on. This selective affinity is analogous to that which prevails among organized ferments, parasitic fungi, and other micro-organisms. In this way it is readily understood that variations in the chemical composition of seeds would entail corresponding changes of enzymic reagents.

We feel that, for the present, our failures are of little value to anyone save ourselves. Each successful experiment, however, has a positive value, quite unaffected by any number of negative results; and a few of these are tabulated below, in the belief that they will be of general interest.

RESULTS OF SUNDRY EXPERIMENTS WITH ENZYMS.

Description of Seeds.	Solution.	Time.*	Per cent. Germination.	Per cent. Gain or Loss.
Tomato, Hundred Day, Twelve years old.	Water	1 week.	12	0
	Pepsin 5% (*c*)	"	70	483
	Pepsin 10% (*d*)	"	80	567
	Diastase 5% (*f*)	"	84	600
	Diastase 10% (*g*)	"	85	608
Tomato, Hundred Day, Twelve years old.	Water	48 hours.	34	0
	Diastase 5% (*f*)	"	70	106
	Diastase and Pepsin (*h*)	"	38	12
Tomato, Long Keeper, Five years old.	Water	25 hours.	36	0
	Diastase 5% (*f*)	"	46	27
Tomato, Early King Humbert, Twelve years old.	Water	24 hours.	14	0
	Diastase 5% (*f*)	"	24	71
Tomato, Essex Hybrid, Nine years old.	Water	24 hours.	0	0
	Diastase 5% (*f*)	"	10	∞
	Extractum Pancreatis (*i*)	"	36	∞
	Trypsin (*j*)	"	4	∞
	Enzymol (*k*)	"	8	∞
	Diastasic Essence Pancreas (*l*)	"	8	∞
Tomato, Long Keeper, Five years old.	Water	24 hours.	76	0
	Extractum Pancreatis (*i*)	"	70	-8
	Trypsin (*j*)	"	70	-8
	Enzymol (*k*)	"	90	18
	Extractum Pancreatis (*m*)	"	80	5
	Trypsin (*n*)	"	86	13
	Enzymol (*o*)	"	80	5
	Diastasic Essence Pancreas (*p*)	"	64	-16
Tomato, Early King Humbert, Twelve years old.	Water	24 hours.	28	0
	Extractum Pancreatis (*i*)	"	34	21
	Trypsin (*j*)	"	56	100
	Enzymol (*k*)	"	44	57
	Extractum Pancreatis (*m*)	"	36	31
	Trypsin (*n*)	"	44	57
	Enzymol (*o*)	"	52	86
	Diastasic Essence Pancreas (*p*)	"	22	-21

*Time during which seeds were allowed to soak in the several solutions before being drained and put into the germination apparatus.

Each sample contained either 50 or 100 seeds.

Cucumber, White Spine, Five years old.	Water	48 hours.	44	0
	Diastase 5% (*f*)	"	54	23
	Diastase and Pepsin (*h*)	"	54	23
Radish, Carmine Erfurt, Six years old.	Water	48 hours.	46	0
	Pepsin 5% (*c*)	"	26	-43
	Pepsin 10% (*d*)	"	28	-39
	Diastase 5% (*f*)	"	60	30
	Diastase 10% (*g*)	"	66	43
Watermelon, Light Icing, Nine years old.	Water	24 hours.	20	0
	Pepsin 5% (*c*)	"	70	250
	Pepsin 10% (*d*)	"	60	200

TENTATIVE GENERALIZATIONS.

The results so far secured are in no respect final, but the experiments already completed give the following general indications:

1. In some cases the percentage of germination in seeds is greatly increased by soaking for several hours in a solution containing some active enzym or enzyms.

2. The vigor of the young plantlets is often enhanced at the same time.

3. Within limits these beneficial effects increase with the strength of the enzym solution.

4. Diastase, either from malt or from various commercial preparations, seems to be most useful.

5. Tomato seeds seem to respond especially well to the action of enzyms, particularly to the action of diastase.

IV. THE PRESERVATION OF FRUITS BY VAPOR OF ALCOHOL.

Experiments were made in the fall and winter of 1894 by Monsieur A. Petit at the National School of Horticulture of Versailles, (France) in the preservation of grapes by exposure to the vapor of common alcohol, which, according to report, gave very striking results.

Briefly the method was this: Freshly picked grapes were placed thinly upon trays of wood shavings in order to offer freer access to the alcoholic vapor. These trays of fruits were placed in a large cellar closet which could be conveniently and securely (not hermetically) closed. A small vessel of alcohol was left uncovered in the room, and the ordinary evaporation from this satisfied the purposes of the experiment. The conditions of temperature and moisture were purposely made the most favorable for the development of mold fungi. Some similar fruit was at the same time placed under the same conditions, with the exception of the alcoholic protection, so as to serve as a check.

The experiment was begun October 31. "On November 20 the grapes in the check were for the most part rotted and covered with mold. In the case containing the alcohol, on the contrary, the grapes looked well as ever, were quite firm, not shrunken, and totally free from mold, they had

no bitterness or bad taste. On December 7 the grapes in the case with alcohol had still their fine appearance, though there were one or two small brown spots to be found. On December 24 there were only a few small spots of mold. The grapes were referred to the judgment of several persons who unanimously pronounced them very fine. The stems remained perfectly green, and the fruits retained their firmness, their volume, and, above all, their flavor. In a word they showed all the qualities of freshly picked grapes."

These statements are quoted from the report of Mr. Petit, made in February, 1895. (See bibliography.) This report immediately attracted wide notice, both in Europe and America. The first to test and report the method in this country was Goff. His experiments were made with plums and showed "that alcoholic vapor is an effectual preventive of the common mold or molds in a damp atmosphere; but the vapor did not prevent, except for a limited time, if at all, other changes within the fruits that destroyed their value."

The first opportunity found by the present writer for a trial of this method of preservation came May 20th, 1896. Beginning at this date six experiments were made as detailed below.

Experiment I.

May 20. Strawberries, bought in the city market (the local crop being yet unripe) were placed under bell jars in four lots as follows: (A) jar sealed* and containing small beaker of alcohol; (B) jar sealed, but without alcohol; (C) jar ventilated below, containing small beaker of alcohol; (D) jar ventilated below and without alcohol.

May 25. Experiment discontinued. The berries in each lot were separated into two classes, those showing no serious mold, and those more or less moldy. The results are shown below:

PERCENTAGE OF SOUND BERRIES.

	TREATMENT.	PER CENT.
A.	Sealed, with alcohol	100
B.	Sealed, without alcohol	19
C.	Unsealed, with alcohol	60
D.	Unsealed, without alcohol	15

The treatment affected the berries in flavor, texture and color. The following notes were taken:

Flavor. All the berries had deteriorated considerably in flavor. Those in C were probably best; those in D, second; and those in B, third. The berries in A were so strongly impregnated with alcohol as to be quite unpalatable.

*Sealed by being placed on ground glass with vaseline. This did not prove to be quite air tight, but permitted slight ingress and egress of air with change of interior temperature.

Texture. The berries in C and D, that is those which were ventilated, seemed to be much firmer than those in A and B. In A they were very soft and mushy.

Color. The alcohol seemed to have a tendency to bleach the berries somewhat. This was most noticeable in A.

After this examination the berries of lot A were returned to their bell jar and kept for several days. When finally abandoned they had lost all form and were quite unsightly. Nevertheless microscopic examination failed to find organisms of any sort. Apparently they had completely spoiled through chemical decomposition (disintegration ?) without the fungi or bacteria which usually are present and hasten decay.

EXPERIMENT II.

May 28. Good, sound strawberries were placed in closed bell jars under the following plan of treatment :

A. Check. No treatment.

B. Contained small vial of alcohol.

C. Contained small beaker of alcohol.

D. Contained small beaker of wood alcohol.

E. Contained small beaker of dilute formalin.

F. Contained waste from platinum waste recovery (dilute impure formic acid and formates).

May 30. Berries were still sweet and sound. None had lost color. This was quite different from the result in Experiment I when poorer berries were used, and when they lost color rapidly.

June 1. The following notes were taken :

A. A trace of mold found, color dulled, texture moderately firm, flavor normal.

B. No mold, color good, texture perfectly firm, a slight trace of alcohol apparent to the taste.

C. No mold, color fading, texture soft, flavor bad.

D. No mold, color quite faded, texture poor, flavor very bad.

E. No mold, color darkened, texture poor, taste watery.

F. A little mold, color good, texture very firm, flavor medium good.

June 2. The following notes were taken :

A. Mold spreading ; some Penicillium fruiting.

B. Losing in color, firmness and flavor, but the color still the best in the series.

C. Conditions same as with B, but more marked.

D. Fading and losing firmness.

E. Color darkening, losing firmness.

F. Mold spreading, some Penicillium fruiting, color and texture fair.

June 5. A and F quite moldy, B in best condition, no mold on B, C, D and E. All are unfit for table use.

June 6. Experiment discontinued. At this time the berries in each lot were separated into two classes, viz : those showing no mold, and those more or less moldy. The berries were also examined to determine the amount of alcohol absorbed. In the following table the amount of alcohol found *in the sound berries* is given, the figures indicating the parts per thousand by weight ; thus in lot C, alcohol was found at the rate of 5.63 lbs. per 1,000 lbs. of fruit.

RESULTS OF EXPERIMENT II.

TREATMENT.	PER CENT. SOUND FRUITS.	ALCOHOL; PARTS PER 1,000.
A. Check ; no treatment	15	0.00
B. Small quantity alcohol	40	0.49
C. Larger quantity alcohol	100	5.63
D. Wood alcohol	100	5.88
E. Formalin	98	0.00
F. Platinum waste recovery fluid	12	0.04

EXPERIMENT III.

June 13. Placed fresh strawberries under bell jars under conditions detailed in next paragraph.

June 24. Discontinued the experiment, making the following notes :

A. Check, without alcohol or other preservative ; 30 per cent. free from mold ; all badly spoiled, soft and mushy ; color medium good.

B. With 5 c.c. alcohol ; much worse than A for some reason not evident; all decayed, mushy, color completely lost.

C. With 10 c.c. alcohol ; better than B, but not so good as A.

D. With 25 c. c. alcohol; a good deal of mold visible ; considerably discolored ; about on a par with C.

E. With small beaker containing alcohol ; no mold ; comparatively well preserved ; better than the others, but quite unfit for use.

EXPERIMENT IV.

June 25. A collection of fruits were placed on trays having wooden slat bottoms, and shut into a small cupboard, containing a beaker with 100 c.c. alcohol at the bottom. The fruits tested in this experiment comprised peaches, apricots, cherries, plums, strawberries and currants.

July 1. Currants somewhat shrivelled ; some strawberries quite moldy,* but others firm and sweet ; one apricot entirely taken with mold,* the others sound ; several peaches decaying but not showing mold ; a few plums spoiling ; cherries, which were rather green, sound.

July 3. Strawberries nearly all spoiled ; currants considerably shrivelled ; apricots still sound ; peaches rapidly spoiling ; plums still mostly sound ; cherries still sound.

July 7. All fruits unfit for use and rapidly rotting.

*Covered with fruiting Penicillium.

EXPERIMENT V.

July 18. In order to observe the disintegration of fruit without the presence of the usual agents of organic decay as noted in Experiment I several raspberries and one cherry were put into two vessels; the first a closed dessicator containing small beaker of alcohol; the second a glass cylinder containing alcohol at the bottom, the berries being supported on glass wool above, and ventilated by air drawn through absorbent cotton by an air pump. The whole apparatus was sterilized one hour at 150° C. before placing the fruit inside.

August 5. This experiment was discontinued. All berries were well preserved, being quite firm and sound, though having lost color somewhat. Those in the ventilated vessel were comparatively free from alcohol, which was present in offensive excess in the other berries.

Cultures made by inoculating sterilized agar-agar with pieces of these fruits proved conclusively that no fungi or bacteria were present.

EXPERIMENT VI.

September 24. Two baskets of grapes, one of Concord and one of Delaware, were placed in the sterilizing oven of the Station creamery on small trays having slat bottoms. The oven has a cubic contents of about two yards. With the grapes 100 c.c. of alcohol was exposed in a beaker. The temperature was quite uneven, being in general that of the pasteurizing room, or a little below. The fruit was examined from time to time, and was judged to be keeping fairly well. A small amount of mold appeared within the first two weeks, but not enough to be of practical consequence. At the end of the first month several berries were molded, but by far the greater part were still sound and sweet.

November 13. Up to this time the grapes kept very well. Though a few berries on nearly every bunch were molded, any bunch might have been easily trimmed so as to be presentable at table. The flavor was fairly well retained.

December 8. Experiment discontinued. At this time very few of the grapes were fit for table. Concords kept better than Delawares throughout.

CONCLUSIONS.

Vapor of alcohol in a closed space will prevent more or less the growth of the fungi and bacteria which usually hasten decay. To be effective it must be present in some appreciable quantity. If present in a considerable quantity the development of fungi and bacteria may be wholly prevented for several days or even weeks. But in this case the fruits, especially those with soft flesh, absorb enough alcohol to render them very disagreeable to the taste. The fruit also deteriorates in color and texture. Although the growth of fungi and bacteria is prevented, other processes of decay seem to be hastened. The method seems to be best adapted to the preservation of grapes; and it is probable that, with sufficient experimentation upon details, it might be made practically effective for special conditions. It is thought that this method might be put to practical use in occasional cases for the

preservation of some other fruits for a very short time. Thus strawberries or raspberries might be placed in a refrigerator for three or four days with a small open vessel of alcohol and be preserved in better condition than without the alcohol.

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1896. **E. S. Goff.** Alcoholic Vapor as a Preservative of Strawberries. Rpt. Wis. Exp. Sta., 1896, p. 235. Negative results. "It would appear that alcohol cannot be used in the method described to prevent mold in strawberries, without at the same time destroying their flavor."

1896. **M. H. Beckwith.** Rpt. Del. Exp. Sta., 8 (1896), p. 109. Kept Norfolk grapes 54 days in good condition but with deterioration of flavor.

November, 1896. **F. A. Waugh.** Bericht ueber die Konservierung von Obstsorten durch Spiritusdampf; Gartenflora (Berlin) vol. 45, p. 578. Brief note of experiments with various fruits. Results mostly negative.

November, 1896. **F. A. Waugh.** Preservation of Fruits by Vapor of Alcohol. Garden and Forest, vol. 9, p. 458. Brief advance notice of experiments more fully reported herewith.

1896. **T. F. Bioletti.** Preservation of Fresh Grapes. Cal. Exp. Sta. Report of the Viticultural Work, 1887-93. Alcohol vapor preserved the good appearance of grapes for five months in hermetically sealed vessels but rendered the fruit unfit for eating.

V. A REPORT ON THE OCCURRENCE OF THE CABBAGE-ROOT MAGGOT.

A considerable number of plants in the experimental plots of cabbage, cauliflower, broccoli and kale were found on the 16th of July, 1896, wilted to the ground in the hot sun. Other plants in the same rows did not seem to be suffering in the least. It was instantly apparent that the wilted plants were involved in some serious difficulty. An examination showed that the roots were attacked and made worthless by the cabbage-root maggot.

This insect is already too well known in America, so that there remained for us little to do either in scientific study of the pest or in taking steps to save our vegetables. The case, however, was serious enough to warrant some attention, and it is doubtless worth while to give a brief account of the insect here in order both to explain sundry cases of damage to cabbage and cauliflower crops and to put gardeners on their guard against more serious outbreaks. In these notes we shall make free use of the matter published by Goff* and others, and especially the very complete resume of the subject by Slingerland.†

The cabbage root maggot (*Phorbia brassicæ* Bouche) is of European origin, having been regarded for many years as one of the worst garden insects in Germany, France and England, especially in Germany. It was introduced into this country, however, at an early period, having been found and described in the United States in 1835. Since then it has been found in nearly all parts of North America, from Nova Scotia to Vancouver Island in Canada, and at such widely distributed points as Alabama, Vermont, and Oregon in the United States. It is reported as having attacked turnips in Vermont in 1887. In many cases the damage has been severe. There are numerous records of the destruction of whole fields of cabbage and cauliflower amounting to many acres.

The insect works not only on cabbage but on many allied plants, including cauliflower, kale, broccoli, brussels sprouts, radishes, turnips, mustard and several weeds of the same family.

The eggs from which the maggots hatch are laid by a small fly much like a common house fly. These eggs are usually deposited on the root of the oung cabbage or cauliflower plants near the surface of the ground and soon after the plants are transplanted to the field. When the maggots hatch they eat into the main root of the plant and soon practically destroy it. The first intimation of their presence is usually the wilting of the leaves in the hot sun.

TREATMENT.

By this time the damage is done and there is but little possibility of applying a remedy. If the wilting is noticed early it is possible to kill the maggots and save the plants by two or three thorough applications of kerosene emulsion which should be made upon the roots after the removal of a considerable amount of earth with a hoe. This is seldom practicable. But as the insect is apt to appear again in subsequent years upon ground where it has once lived the gardener may take timely warning and adopt preventive measures which are much more satisfactory. The best of these is thought to be that brought to notice by Goff (loc. cit.) and consists in protecting each plant by a small piece of tarred paper put about the stem just on top of the ground at transplanting time. These bits of paper, if pro-

*Rpts. Wis. Exp. Sta., 9 (1892), p. 169; 11 (1894), p. 259.
†Bul. Cornell Exp. Sta., 78 (1894).

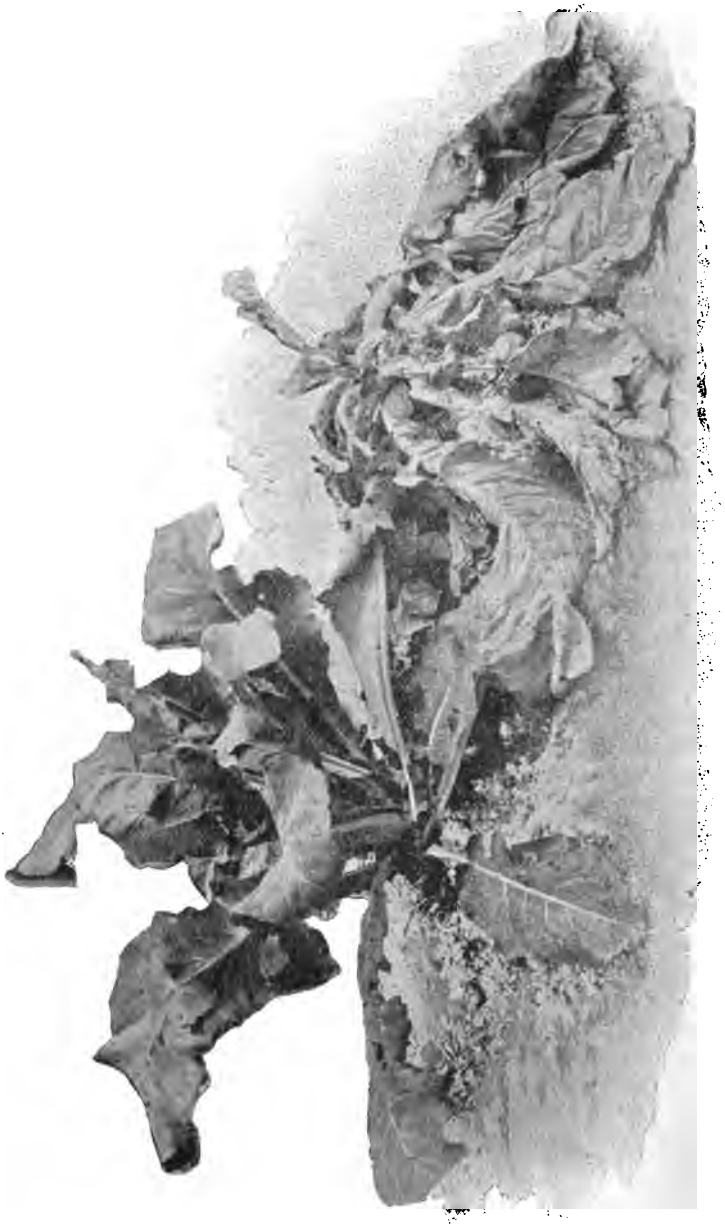


Fig. 8. Kale plants. The one at the right is attacked by cabbage-root maggots; the one at left is still free. Photographed in the field.

perly applied, prevent the female fly from reaching a point on the stem where she may place her eggs. A very simple tool for cutting suitable cards of tarred paper has been devised by Goff, so that this method of prevention has been made thoroughly practicable for large or small areas. Whenever possible to avoid it cabbages or similar plants should never be planted on ground where the cabbage-root maggot has been at work the year before.

The illustration (Fig. 8) is from a photograph made on the station grounds, and gives so good an idea of the appearance of affected plants that no one should have difficulty in the diagnosis of similar cases.

VI. THE "ITALIAN" OR "ORCHID-FLOWERING" CANNAS.

No race of ornamental plants in recent years has awakened such a widespread interest at its introduction as the new and distinct type variously known as "Italian," "orchid-flowering," or "giant-flowering" cannas. The first variety announced was Italia, produced by Mr. Sprenger, of the firm of Dammann & Co., in Italy.* The variety Austria followed soon, however, and these have now been widely disseminated in the United States, being advertised in all the leading plant catalogues of 1897. It was a remarkable coincidence that, at almost precisely the same time when these strange varieties were produced in Italy, Mr. Luther Burbank of California should have produced the variety Burbank very much like them, *and by crossing the self-same parent forms!* This peculiar race thus had two perfectly independent though simultaneous origins. The variety Burbank has been introduced this year by J. C. Vaughan, of Chicago and New York. Dammann & Co., the introducers of Italia and Austria, have more recntly introduced several additional varieties of the same class, the best known of which are Alemannia, America, Bavaria, Burgundia, La France and Pandora. These varieties are not as yet advertised in America.



Fig. 9. Canna flaccida, about half size.

*The first announcement of these plants in the horticultural press seems to be that of Revue Horticole (Paris) 67, p. 31, (Jan. 16, 1895). The first general account of the race was published in Revue Horticole 67, p. 516, (Nov. 16, 1895). Additional notes and a chromolithograph appeared in the same journal Feb. 16, 1896.

The most striking and important characters of these new cannas are these: Blossoms of immense size, often from 5 to 6 inches in diameter; (some of the advertisements say 7 inches and more, but this is improbable); flowers broadly opened; the petal-like staminodia very broad and full, giving a flower of a magnificent form hitherto quite unapproached in cannas; usually much reflexed corolla lobes; peculiarly rich and clear colors; an unfortunate softness and fragility of the blossoms which, in our climate, seldom spares them for an entire day; large, broad, tough musa-like foliage; general tall growth

The breeding of this race is somewhat remarkable. The so-called "French dwarf" cannas, which have become so popular in America in recent years, have been crossed and hybridized "in and in" until all the possibilities of the several parent species have become quite exhausted. In this condition an out cross with a species not before used was the evident part of wisdom. This out cross was made, both in Italy and California, upon the well known variety Madame Crozy, and with the pollen of *Canna flaccida*,* a species growing wild in the southern United States.

The soft, evanescent blossoms of *Canna flaccida* have been imparted to all the crosses thus far secured, but the race has been distinctly reinvigorated, and there have been developed striking and desirable characters till now unknown.

It would be of considerable theoretical and practical consequence could we, in this connection, know the full pedigree of Madame Crozy, the seed-bearing parent in these crosses. Unfortunately this pedigree is only a matter of speculation, and seems likely to remain so. The general opinion among students in this branch of horticulture seems to be

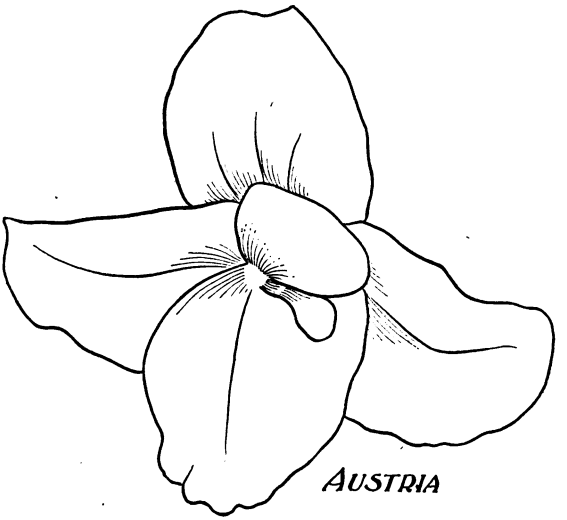


Fig. 10. Outline of blossom of Austria, about two-thirds natural size. Compare with Italia and Madame Crozy opposite.

Canna flaccida Salisbury. "Wild in swamps, S. Car, S., 2-4 feet high, with ovate-lanceolate, pointed leaves, and yellow flowers 3-4 inches long; all the inner divisions obovate and wavy, lax, the three corolla lobes reflexed."—Gray's Field, Forest, and Garden Botany.

that there are two groups of the "French dwarf" cannas, the red-flowering ones, including Madame Crozy, having originated by crossing *Canna ehmanni* with *Canna warscewiczii*, while the yellow-flowering varieties are thought to have sprung from crosses of *C. ehmanni* with *C. glauca*.* If this view is taken of the origin of the "orchid-flowering" cannas, their complete pedigree will be *approximately* expressed in the diagram at the head of the next page.

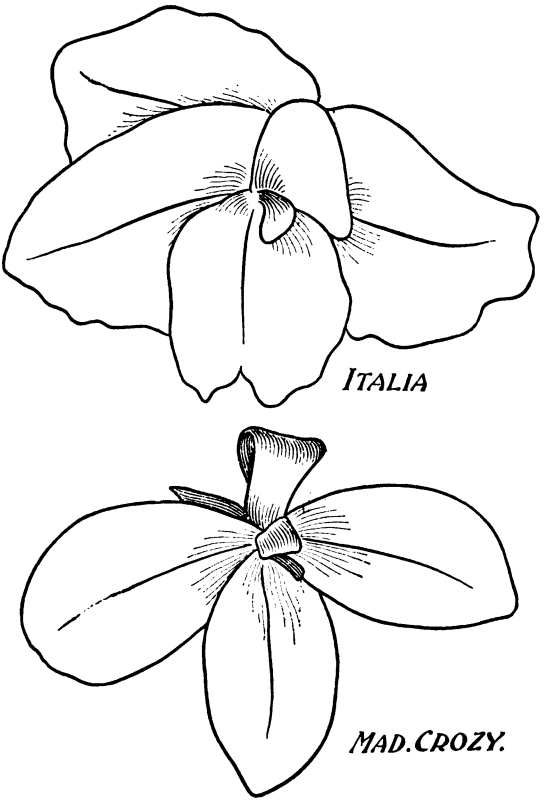
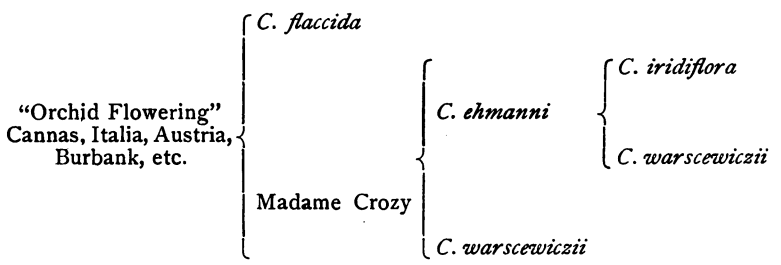


Fig. 11. Outlines of blossoms of Italia and Madame Crozy, about two-thirds natural size, all reduced in the same proportion from a photograph. These plants, together with Austria shown on the opposite page all grew in the same bed.

Antoine Crozy, the originator of Madame Crozy and many leading varieties of that class, is, however, quoted in a recent interview as saying that he began by crossing *Canna wasrcewiczii* and *C. neapelensis*, and that his yellow spotted varieties were secured by subsequent crossing with *C. aureo-picta*, which is probably a horticultural form of *C. indica*, the old-fashioned "Indian shot."

This station has found opportunity in its greenhouse and on its ornamental grounds to grow several of the new "orchid-flowering" varieties, and to compare them in flower and foliage with the best of the

*In this connection the following extract from a private letter from the eminent horticulturist, M. Henry L. de Vilmorin, will be of interest: "It is the current belief in this country [France], and it seems confirmed by experiment that the new breed of floriferous cannas [*i. e.*, the "French dwarfs,"] originated by the crossing of *Canna ehmanni* with *C. warscewiczii* and with *C. glauca*, the former producing the red-flowered, and the latter specially yellow-flowered varieties. Both original crosses intercross readily, and in latter years I have had many crosses made every year, and raised and named several dozen new seedlings, using the best varieties of my own and Crozy's raising without introducing new blood into the breed."



older standard varieties. Our opinion of them is, in general, that the varieties thus far introduced cannot become so widely useful as the "French dwarfs," and that they in no sense supersede the older varieties; that they are nevertheless a highly valuable addition to the list of ornamental plants; that they will be abundantly attractive to flower lovers and useful to plant breeders as the basis for further crosses. We are especially pleased with the *form* of the flowers, which is peculiarly full, graceful and satisfactory, and with the *colors*, which have a velvety richness rarely equaled in nature or in art.

The following varieties have blossomed on our grounds, and the descriptions represent the plants as they develop here. We have several other varieties which have not yet blossomed.

ITALIA.—3-4 feet high, foliage broad, bright glaucous green; flowers very large, exceptionally well opened, with very broad and gracefully rounded staminodia (looking like petals), color a bright canary yellow, with dark cherry red filling the center, and running out in blotches upon the petal-like staminodia.

AUSTRIA.—Plant like Italia: flowers lemon yellow, lighter than Italia, marked only with faint dots of pink in the throat. The flower does not expand so well as in Italia, and the form is not quite so good; but the coloring is very delicate and desirable.

BURBANK.—Plant like Italia; flowers large, much like Italia in form and like Austria in coloring; rich canary yellow, with light red dots and markings in the throat.

AMERICA.—Foliage dark, bronzy-red, with irregular dashes of dull green; flowering stem tall; flowers of the form and size of Italia, brilliant apricot red, faintly spotted with darker salmon; the center is canary yellow, marked with the apricot red of the body color. The blossoms of this variety, in our opinion, exceed in richness of coloring any of the others which we have seen.

VII. A NEW GRAFTING MACHINE.

A grafting machine has long been a desideratum in horticulture, so that a strong practical interest attaches to each new contrivance proposed. We have been using experimentally and for illustration with classes in horticulture in the University an ingenious tool invented by M. L. Pradines, Levallois-Perret, France. This implement was first figured and described in France in 1895,* and has since been briefly noted from this station.†

*Ed. Andre, Revue Horticole, 67 (1895), p. 67.

†F. A. Waugh, Rural New Yorker, Nov. 28, 1886. The figure reproduced upon the next page was made from our photograph for the Rural New Yorker, and we are indebted to the publishers for its use here.

The construction of this grafting machine will be best understood from the figure. The general resemblance to a common pair of pruning shears will strike one at once. It is about the size of a Wiss No. 3 pruner, and weighs a trifle over fourteen ounces. It is light and easy to manage. The machine was designed for use in grafting grapes; but as grafting is seldom practiced on grapes in this country, outside of California, its usefulness on other plants is of more direct consequence. We have made several tests of the tool in an experimental way, but never on a large scale. We have found that the first oblique cut as made in the "whip graft" (the ordinary method of root graftage) or in the "splice graft," upon either stock or scion, may be quickly, easily, and accurately made. But the present construction does not enable the operator readily to make the second cut for the "tongue" of the graft, though this may be awkwardly accomplished after some practice. The machine does not make any of the cuts used in cleft grafting, as commonly practiced in renewing tree tops. It cannot be expected to be a profitable substitute for the skilled graftsman with the commercial propagator; but some modification of the present construction might give a tool which would be quite useful to the common farmer, orchardist or gardener, who can not always be an expert at all the practices of budding and grafting. At present it is a pointed suggestion to the inventive horticulturist rather than an accomplished practical success.

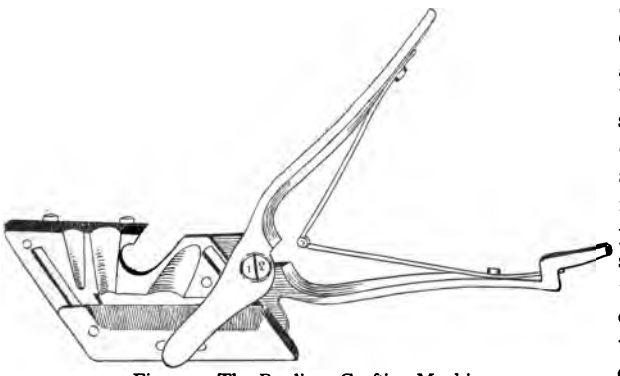


Fig. 11. The Pradines Grafting Machine.

APPENDIX TO REPORT OF HORTICULTURIST.

TABLE I. RECORD OF PROTECTED BLOSSOMS.

Denton, Md., 1897.

VARIETIES.	Blossoms covered.	Fruit set.	Crop set by unprotected blossoms.
JAPANESE GROUP.			
Chabot	57	0	Good
"	102	0	Good
Kerr	92	0	Scant
Maru	166	0	Heavy
"	61	0	Heavy
Totals	478	0	
AMERICANA GROUP.			
Apricot	60	0	Very few
Champion	28	0	Moderate
Cottrell	56	0	None
Forest Garden	44	0	Good
Gaylord	162	0	Heavy
Hammer	149	0	Light
Hawkeye	32	0	Good
Heaton	123	0	Heavy
Kieth	73	0	Heavy
Le Duc	87	0	None
"	53	0	Good
Leonard	108	0	Moderate
Old Gold	88	?	?
Rockford	63	0	Heavy
"	41	0	Good
Rocky Mt. Dwarf	*200	1	Heavy
Rollingstone	27	0	Light
"	32	0	Light
Van Buren	46	0	Heavy
Van Deman	105	0	Good
Wildrose	137	0	None
Totals	1709	1	
NIGRA GROUP.			
Cheney	88	0	Good
Itasca	*100	0	None
Totals	188	0	
MINER GROUP.			
Idall	102	0	Moderate
Indiana Red	25	0	Moderate
Miner	194	1	Moderate
"	35	0	Moderate
"	33	0	Good
Prairie Flower	73	0	Moderate
Totals	462	1	

*Estimated.

VARIETIES.	Blossoms covered.	Fruit set.	Crop set by unprotected blossoms.
WAYLAND GROUP.			
Garfield	143	0	Heavy
Kanawha	68	0	None
Leptune	50	0	Good
Missouri Apricot	133	0	Heavy
Wayland	103	1	Heavy
"	154	0	Heavy
"	134	0	Heavy
Worldbeater	36	0	Light
"	36	0	Light
Totals	856	1	
WILDGOOSE GROUP.			
Chas. Downing	24	0	Moderate
"	43	0	Moderate
Dunlap's No. 2	72	0	Good
Freeman's Favorite	20	0	Moderate
Jas Vick	111	0	Moderate
Ohio Prolific	133	0	Heavy
Osage	142	0	Moderate
Schley	45	0	Scant
Smiley	203	0	Light
Sophie	126	0	Light
"	49	0	Light
Texas Belle	42	0	Heavy
Wildgoose	155	0	Heavy
"	142	0	Heavy
Totals	1316	0	
CHICASAW GROUP.			
African	102	0	Good
Arkansas Lombard	168	0	Good
Coletta	78	0	Moderate
Early Red	77	0	Good
"	73	0	Good
El Paso	76	0	Scant
Munson	103	0	Good
"	58	0	Moderate
"	69	0	Light
Newman	232	0	Good
Ogeechee	41	0	Light
"	103	0	Light
Piram	52	0	Scant
Pottawattomie	74	0	Heavy
Robinson	63	2	Good
Totals	1419	2	
MISCELLANEOUS.			
Hattie	42	0	Scant
"	47	0	Scant
P. maritima	*300	0	Heavy
Imp. Dwf. Rocky M't'n Cherry (*P. besseyi*)	*200	1	Heavy

*Estimated.

TABLE II. SHOWING VARIATIONS IN PISTILS.

DOMESTICA GROUP.

Average defectiveness of pistils for the entire group, 43 per cent.

Variety.	% Defective.	Remarks.	Varieties.	% Defective.	Remarks.
BRADSHAW, AVERAGE.	22		COE'S GOLDEN DROP,		
State Coll., Pa., '97	45	Multiple	AV.	3	
Geneva, N. Y., '97	0	styles.	Denton, Md., '97	0	Long styles.
COMMUNIA,			State Coll., Pa., '96	12	
Manhattan, Kan., '97	0		do. '97	0	
EARLY RED,			Orono, Me., '96	0	
Orono, Me., '96	0		DIAMANT PLOMMEN,		
FELLENBERG PRUNE,			Copenhagen, '97	13	Long styles.
Phœnix, Ariz., '97	0				
GERMAN PRUNE, AV.	0		EXPERIMENTAL FATTELS SVISKOV,		
State Coll., Pa., '97	0		Copenhagen, '97	3	
Wolfville, N. S., '97	0				
GREEN GAGE, AV.	3		GEN. HAND, AV.	0	
Parry, N. J., '97	0		Denton, Md., '97	0	Long styles.
Agl. Coll., Mich., '96	10		State Coll., Pa. '97	0	
Madison, Wis., '96	0		Geneva, N. Y., '97	0	
IMPERIAL GAGE, AV.	4		GOLDEN PRUNE, AV.	0	
Blacksburg, Va., '97	9	Long styles.	Santa Rosa, Cal., '97	0	
State Coll., Pa., '96	0		Pullman, Wash., '97	0	
do. '97	6	Long styles.	GRAND DUC, AV.	10	
Geneva, N. Y., '97	0	Long styles.	Amherst, Mass., '96	12	
LOMBARD, AV.	4		Copenhagen, '97	9	
Blacksburg, Va., '97	29		JEFFERSON, AV.	2	
Parry, N. J., '97	0		Phœnix, Ariz., '97	0	
State Coll., Pa., '96	0	Proterogy-	Geneva, N. Y., '97	7	Long styles.
do. '97	2	nous.	Dublin, Ireland, '97	0	Long styles.
Logan, Utah, '97	0		MOORE'S ARCTIC, AV.	7	
Geneva, N. Y., '97	0		Denton, Md., '97	0	
Wolfville, N. S., '97	0	Long styles.	State Coll., Pa., '96	0	
POND'S SEEDLING, AV.	12		do. '97	0	
State Coll., Pa., '97	30		Madison, Wis., '94	5	
Amherst, Mass., '96	20		Springfield, Vt., '97	0	Long styles.
Geneva, N. Y., '97	0		Stevensville, Mont.,		
Orono, Me., '96	0		'96	15	Proterogy-
PURPLE DAMSON, AV.	15		Wolfville, N. S., '97	29	nous.
State Coll., Pa., '96	30	Proterogy-	PRECOCE BERTHOLD,		
do. '97	0	nous.	AV.	3	
QUACKENBOSS, AV.	0		Phœnix, Ariz., '97	0	
Geneva, N. Y., '97	0		Copenhagen, '97	6	
Orono, Me., '96	0		RICHLAND, AV.	0	
REINE CLAUDE, AV.	4		Denton, Md., '97	0	Long styles.
Blacksburg, Va., '97	11	Long styles.	Parry, N. J., '97	0	Long styles.
Denton, Md., '97	0	Long styles.	Manhattan, Kan., '96	0	
Copenhagen, '97	0		Ottawa, Ont., '97	0	
SHIPPER'S PRIDE, AV.	0		SHROP. DAMSON, AV.	2	
Geneva, N. Y., '97	0		Morgantown, W.		
Springfield, Vt., '97	0		Va., '96	0	
SPAULDING, AV.	2		Parry, N. J., '97	5	
Denton, Md., '97	0	Long styles.	State Coll., Pa., '97	0	
Parry, N. J., '97	0	Long styles.	Wolfville, N. S., '97	5	
State Coll., Pa., '97	5	Long styles.	VESTMANLAND'S ROED		
WASHINGTON, AV.	8		PLOMMEN,		
St. Louis, Mo., '96	0		Copenhagen, '97	0	
" '97	0		WHITE NICHOLAS, AV.	0	
State Coll., Pa., '97	7		Pullman, Wash.,		
Geneva, N. Y., '97	0		'97	0	
Amherst, Mass., '96	29		Madison, Wis., '94	0	
Copenhagen, '97	10	Long styles.	do. '96	0	
YELLOW EGG, AV.	9		Orono, Me., '96	0	
Blacksburg, Va., '97	42	Long styles.			
State Coll., Pa., '96	0				
do. '97	0				
Geneva, N. Y., '97	3	Long styles.			
Orono, Me., '96	0				

JAPANESE GROUP.

Average defectiveness of pistils for the entire group 11.2 per cent.

Varieties.	% Defective.	Remarks.	Varieties.	% Defective.	Remarks.
ABUNDANCE, AVERAGE.	5		BURBANK, AV.	13	
Denison, Tex., '96	17		Denison, Tex., '97	27	
do. '97	0		Santa Rosa, Cal., '97	0	
Auburn, Ala., '97	0		Starkville, Miss., '97	9	
Augusta, Ga., '97	0		Auburn, Ala., '97	36	
Phœnix, Ariz., '97	10	Long styled.	Phœnix, Ariz., '97	5	
Manhattan, Kan., '97	16		Manhattan, Kan., '97	21	
Santa Rosa, Cal., '97	0		Denton, Md., '97	2	Long styled.
Parry, N. J., '97	0	Long styled.	do. (tree dying) '97	58	Long styled.
Amherst, Mass., '97	0		Parry, N. J., '97	0	Long styled.
BERCKMAN'S,			Geneva, N. Y., '97	0	
Denison, Tex., '97	7		North Ferrisburgh, Vt., '97	0	
BURBANK SEEDLING,			BAILEY,		
Santa Rosa, Cal., '97	0		Augusta, Ga., '97	45	
CHABOT, AV.	17		BLOOD PLUM,		
College Sta., Tex. '96	0		Auburn, Ala.,	0	
Auburn, Ala., '97	17		DELAWARE,		
Phœnix, Ariz., '97	50		Santa Rosa, Cal., '97	0	
Starkville, Miss., '97	0		HALE, AV.	9	
GEORGESON, AV.	12		Denison, Tex., '97	19	Long styled.
Augusta, Ga., '97	14		Santa Rosa, Cal., '97	0	
Phœnix, Ariz., '97	0	Long styled.	KELSEY, AV.	2	
Denton, Md., '97	0	Long styled.	Denison, Tex., '97	0	
Amherst, Mass., '96	36		Denton, Md., '97	4	
KERR, AV.	17		MARU,		
College Sta., Tex., '96	25		Denton, Md., '97	0	
Denton, Md., '97	9		OGON, AV.	6	
NORMAND,			Manhattan, Kan., '97	9	
Denton, Md., '97	0	Long styled.	Denton, Md., '97	4	
RED JUNE,			LaFayette, Ind., '97	0	
Denton, Md, '97	73		Parry, N. J., '97	0	
SATSUMA, AV.	11		Geneva, N. Y., '97	10	
Denison, Tex., '97	0		Minn. City, Minn., '96	12	
Phœnix, Ariz., '97	3		RED NAGATE,		
Denton, Md., '97	0	Long styled.	Augusta, Ga., '97	10	
Santa Rosa, Cal., '97	0		WICKSON, AV.	0	
Parry, N. J., '97	50		Denison, Tex., '97	0	
WILLARD,			Santa Rosa, Cal., '97	0	
Parry, N. J., '97	0	Long styled.	Parry, N. J., '97	0	Long styled.
SEEDLING OF BURBANK AND SATSUMA,			YOSEBE,		
Santa Rosa, Cal., '97	0		Denison, Tex., '97	20	

AMERICANA GROUP.

Average defectiveness of pistils for the entire group 21.2 per cent.

BLACKHAWK,			CHAMPION,		
Ottawa, Ont., '96	30		Denton, Md., '97	0	
CHEROKEE,			COLORADO QUEEN,		
Denton, Md., '97	0		Denton, Md., '97	5	
COMFORT, AVERAGE.	20		COTTRELL,		
Denton, Md., '97	0		Minn. City, Minn., '97	37	
Ottawa, Ont., '96	60		DES MOINES,		
do. '97	0		Denton, Md., '97	0	
DEEPCREEK, AV.	25		DUNLOP'S NO. 1,		
Phœnix, Ariz., '97	0		Ottawa, Ont., '97	50	
Denton, Md., '97	78	Short styled.	FOREST GARDEN, AV.	26	
Parry, N. J., '97	9	Short styled.	Denton, Md., '97	21	
Ottawa, Ont., '97	13		Parry, N. J., '97	0	
DE SOTO, AV.	18		Madison, Wis., '94	3	
Geneva, N. Y., '96	0		Orono, Me., '97	15	
Minn. City, Minn., '96	14		Ottawa, Ont., 96	90	

Variety.	% Defective.	Remarks.
Madison, Wis., '96	92	
Agl. Coll., Mich., '96	10	
La Fayette, Ind., '97	27	
North Ferrisburgh, Vt., '96	15	
Pullman, Wash., '97	5	
Amherst, Mass., '97	0	
Orono, Me., '97	8	
Ottawa, Ont., '96	10	
HAWKEYE, AV.	2	
Denton, Md., '97	0	
Parry, N. J., '97	7	
Geneva, N. Y., '96	0	
Minn. City, Minn., '96	0	
Amherst, Mass., '96	10	
do. '97	0	
Pullman, Wash., '97	0	
Orono, Me., '97	0	
Ottawa, Ont., '96	0	
ILLINOIS IRONCLAD, AV.	2	
Santa Rosa, Cal., '97	0	
Denton, Md., '97	5	
KAMPESKA,		
Denton, Md., '97	20	
KIETH,		
Denton, Md., '97	0	
LE DUC, AV.	44	
Denton, Md., '97	100	Young tree.
do. '97	18	
Madison, Wis., '94	25	
do. '96	40	
MARION,		
Denton, Md., '97	50	
MINNESOTA, AV.	65	
Geneva, N. Y., '96	40	
North Ferrisburgh, Vt., '96	90	
NELLIE,		
Denton, Md., '97	24	
NOYES',		
Denton, Md., '97	15	
OCHEEDA, AV.	28	
Minn. City, Minn., '96	20	
Madison, Wis., '94	8	
" '96	57	
QUAKER, AV.	5	
Logan, Utah, '97	0	
Parry, N. J., '97	7	
Geneva, N. Y., '96	0	
Madison, Wis., '94	6	
do. '96	14	
ROCKFORD, AV.	0	
Denton, Md., '97	0	
Parry, N. J., '97	0	
Minn. City, Minn., '96	0	
Ottawa, Ont., '96	0	
do. '97	0	
SPEER, AV.	50	
Denton, Md., '97	3	
La Fayette, Ind., '97	48	
Ottawa, Ont., '96	100	
TAYLOR,		
Minn. City, Minn., '96	30	
GAYLORD, AV.	40	
Minn. City, Minn., '96	50	
Denton, Md., '97	30	
HAMMER, AV.	2	
Denton, Md., '97	0	
Parry, N. J., '97	3	
HANSON,		
Denton, Md., '97	0	
HEATON,		
Denton, Md., '97	7	
HILLTOP,		
Denton, Md., '97	0	
HUNT,		
Ottawa, Ont., '96	30	
HIAWATHA,		
Denton, Md., '97	46	
HOMESTEAD, AV.	22	
Madison, Wis., '94	19	
do. '96	25	
JONES' LATE,		
Denton, Md., '97	30	
KICKAPOO, AV.	0	
Denton, Md., '97	0	Long styled.
Parry, N. J., '97	0	Long styled.
KOPP,		
Denton, Md., '97	18	
LOUIS, AV.	3	
Denton, Md., '97	0	
Parry, N. J., '97	0	
Madison, Wis., '96	0	
Ottawa, Ont., '97	12	
MILLER,		
Denton, Md., '97	33	
MINNETONKA,		
Denton, Md., '97	0	
NEWTON EGG,		
Denton, Md., '97	18	
OLD GOLD,		
Denton, Md., '97	3	
PURPLE YOSEMITE,		
Denton, Md., '97	0	
PILOT,		
Geneva, N. Y., '96	12	
RECHE,		
Denton, Md., '97	35	
ROLLINGSTONE, AV.	25	
Denton, Md., '97	13	
Lincoln, Neb., '97	9	
La Fayette, Ind., '97	0	
Minn. City, Minn., '96	100	
Madison, Wis., '96	12	
North Ferrisburgh, Vt., '96	40	
Orono, Me., '97	0	
STODDARD, AV.	11	
Denton, Md., '97	22	
Geneva, N. Y., '96	0	
VAN BUREN, AV.	35	
Denton, Md., '97	0	
Parry, N. J., '97	30	
Orono, Me., '96	20	
do. '97	35	
Ottawa, Ont., '96	90	Pistils rudimentary.
WILLIAMS' NO. 17,		

Varieties.	% Defective.	Remarks.	Varieties.	% Defective.	Remarks.
WEAVER, AV.	6		Denton, Md., '97	5	
Denison, Tex., '96	25		WOLF, AV.	15	
Manhattan, Kan., '96	0		Denton, Md., '97	5	Long styled.
Minn. City, Minn., '96	0		Logan, Utah, '97	9	
Amherst, Mass., '96	0		Parry, N. J., '97	5	Long styled.
do. '97	8		Geneva, N. Y., '96	22	
Orono, Me., '97	2		Minn. City, Minn., '96	37	
WINNEBAGO,			La Fayette, Ind., '97	0	
Denton, Md., '97	57		Madison, Wis., '94	9	
P. americana (species) AV.	32		do. '96	56	
Lake City, Fla., '97	33		Amherst, Mass., '96	30	
Auburn, Ala., '97	7		do. '97	5	
Morgantown, W. Va., '96	0	Pistils very slender.	North Ferrisburgh, Vt., '96	17	
do. '97	0		Orono, Me., '96	0	
Stillwater, Okla., '96	40		do. '97	0	
do. '97	5		WYANT, AV.	19	
Biltmore, N. C., '97	40		Manhattan, Kan., '96	0	
Manhattan, Kan., '96	40		Parry, N. J., '97	0	
St. Louis, Mo., '96	56		Minn. City, Minn., '96	28	
Lincoln, Neb., '97	64		Madison, Wis., '94	16	
Madison, Wis., '96	90		do. '96	60	
Denton, Md., (fl. pl.) '97	100		Pullman, Wash., '97	0	
Ottawa, Ont., '96	0		Orono, Me., '97	35	
do. Lot I., '96	60		Ottawa, Ont., '96	10	
do. Lot II., '96	10		YOSEMITE PURPLE, Ottawa, Ont., '96	90	
Copenhagen, '97	0		YELLOW YOSEMITE,		
do. (fol. var.) '97	0	Long styled.	Denton, Md., '97	27	

NIGRA GROUP.

Average defectiveness of pistils for the entire group, 17 per cent.

CHENEY, AVERAGE.	17		ITASCA,		
Logan, Utah, '97	0		Denton, Md., '97	5	
Denton, Md., '97	33		SMITH'S RED, AV.	4	
Parry, N. J., '97	41		Madison, Wis., '94	8	
Lincoln, Neb., '97	43		do. '96	0	
Pullman, Wash., '97	0		*P. americana nigra*,		
Geneva, N. Y., '96	0		(species) AV.	6	
do. '97	0		State Coll., Pa., '96	0	Pistils slender.
Minn. City, Minn., '96	28		do '97	0	
Orono, Me., '97	4		Madison, Wis., '96	10	
Ottawa, Ont., '96	20		Charlotte, Vt., '96	0	
WILLIAMS,			Grand Isle, Vt., '96	0	
Denton, Md., '97	23		North Ferrisburgh, Vt., '97	12	
WAZATA,			Stevensville, Mont.,		
Denton, Md., '97	47		'96	20	

MINER GROUP.

Average defectiveness of pistils for entire group, 1.9 per cent.

Variety.	% Defective.	Remarks.	Variety.	% Defective.	Remarks.
CLINTON, AVERAGE.	5		FOREST ROSE, AV.	8	
Parry, N. J., '97	0		State Coll., Pa., '97	0	
Agl. Coll., Mich., '97	10		Madison, Wis., 94	5	
IDALL,			Agl. Coll., Mich., '97	19	
Denton, Md., '97	0		IRIS,		
INDIANA RED, AV.	0		Denton, Md., '97	0	
Denton, Md., '97	0		MINER, AV.	3	
Parry, N. J., '97	0		Denton, Md., '97	0	
MAQUOKETA, AV.	1		State Coll., Pa., '97	10	
Denton, Md., '97	0		Parry, N. J., '97	3	
Geneva, N. Y., '96	0		Agl. Coll., Mich., '96	0	
Madison, Wis., '94	5		Madison, Wis., '94	4	
do. '96	0		PRAIRIE FLOWER, AV.	7	
PARSONS,			Denton, Md., '97	0	
Denton, Md., '97	0		Amherst, Mass., '96	0	
RACHEL,			do.	20	
Denton, Md., '97	0				

WAYLAND GROUP.

Average defectiveness of pistils for the entire group, 10.5 per cent.

COLUMBIA,			CUMBERLAND,		
Denton, Md., '97	15		Parry, N. J., '97	15	
GARFIELD, AVERAGE.	17		GOLDEN BEAUTY, AV.	19	
Denton, Md., '97	25	Long styled.	Phœnix, Ariz., '97	8	
Parry, N. J., 97	10		Denton, Md., '97	45	
Amherst, Mass., '97	15		Manhattan, Kan., '96	10	
Agl. Coll., Mich., '96	0		Parry, N. J.,	10	
do. '97	37		Agl. Coll., Mich., '97	24	
KANAWHA, AV.	7		LEPTUNE,		
Denton, Md., '97	15		Denton, Md., '97	0	
Parry, N. J., '97	0		REED,		
MISSOURI APRICOT, AV.	1		Denton, Md., '97	0	Long styled.
Denton, Md., '97	2		WAYLAND, AV.	2	
Parry, N. J., '97	0		Denison, Tex., '96	0	
MOREMAN, AV.	38		Santa Rosa, Cal., '97	5	
Manhattan, Kan., '96	12		Denton, Md., '97	0	
Denton, Md., '97	29		WORLDBEATER, AV.	12	
Parry, N. J., '97	0		Logan, Utah, '97	0	
Madison, Wis., '24	71		Parry, N. J., '97	20	
Ottawa, Ont., '96	80		Amherst, Mass., '97	0	
SUCKER STATE,			North Ferrisburgh,		
Denton, Md, '97	0		Vt., '96	30	

WILDGOOSE GROUP.

Average defectiveness of pistils for the entire group, 19.8 per cent.

			CLARK, AV.	0	
CHAS. DOWNING, AV.	20		Denton, Md., '97	0	
Santa Rosa, Cal., '97	40		Parry, N. J., '97	0	
Denton, Md., '97	0		FREEMAN'S FAVORITE,		
CLIFFORD, AV.	36		Denton, Md., '97	10	
Denison, Tex., '96	70		INDIAN CHIEF,		
do. '97	65		Denton, Md., '97	0	
Manhattan, Kan., '97	8		MILTON, AV.	14	
Denton, Md., '97	0		Denison, Tex., '97	0	
JAS. VICK,			Santa Rosa, Cal., '97	0	
Denton, Md., '97	0		Denton, Md., 97	0	
JEWELL,			Parry, N. J., '97	55	
Denton, Md., '97	24		POOLE'S PRIDE, AV.	19	
RED GAGE,			Denton, Md., '97	3	
Ottawa, Ont., '96	100		Parry, N. J., '97	33	
WHITAKER,			Agl. Coll., Mich., '97	20	
Parry, N. J., '97	5		ROULETTE,		

Variety.	% Defective.	Remarks.	Variety.	% Defective.	Remarks.
WILDGOOSE, AV.	11		Parry, N. J., '97	0	
College Sta., Tex., '96	0		SCHLEY, AV.	6	
Denison, Tex., '96	0		Denton, Md., '97	0	
Stillwater, Okla., '96	10		Parry, N. J., '97	12	
Phœnix, Ariz., '97	34		SOPHIE,		
St. Louis, Mo., '96	0		Denton, Md., '97	13	
Blacksburg, Va., '97	19		WILDER, AV.	0	
Morgantown, W. Va., '97	0		Denton, Md., '97	0	
Parry, N. J., '97	0		Ottawa, Ont., '97	0	
Lincoln, Neb., '97	15		WOOTEN, AV.	12	
Amherst, Mass., '96	0		Denison, Tex., '96	14	
do. '97	14		Stillwater, Okla., '97	0	
Madison, Wis., '94	38		Denton, Md., '97	24	
" " '96	9		Parry, N. J., '97	10	
			WILDGOOSE SEEDLING,		
			Denison, Tex., '96	87	

CHICASAW GROUP.

Average defectiveness of pistils for the entire group 10.5, per cent.

AFRICAN,			ARKANSAS LOMBARD,		
Parry, N. J., '97	5		AV.	2	
CADDO CHIEF, AVER'GE.	7		College Sta., Tex., '96	0	
College Sta., Tex., '97	5		Parry, N. J., '97	4	
Pomona, Calif., '97	0		COLETTA,		
Phœnix, Ariz., '97	13		Parry, N. J., '97	0	
Denton, Md., '97	10		EMERSON, AV.	15	
MUNSON, AV.	39		Denison, Tex., '97	29	
Denison, Tex., '97	81		Denton, Md., '97	0	
College Sta., Tex., '97	8		EARLY RED,		
Parry, N. J., '97	27		Denton, Md., '97	75	
OGEECHEE,			HOFFMAN,		Short styled.
Denton, Md., '97	14		Denison, Tex., '97	50	
POTTAWATTOMIE, AV.	6		HUGHES,		
Stillwater, Okla., '97	0		Parry, N. J., '97	15	
Denton, Md., '97	0		JESSIE,		
Parry, N. J., '97	0		Ottawa, Ont., '96	0	
Lincoln, Neb., '97	0		JENNIE LUCAS,		
Agl. Coll., Mich., '97	0		Parry, N. J., '97	12	
Madison, Wis., '94	4		LONE STAR, AV.	41	
do. '96	0		College Sta., Tex., '97	35	
Amherst, Mass., '96	0		Denison, Tex., '97	0	Pistils rudimentary.
do. '97	0	Long styled.	Santa Rosa, Cal., '97	60	
North Ferrisburgh, Vt., '96	50		Denton, Md., '97	36	
ROBINSON SEEDLING,			Parry, N. J., '97	75	
Santa Rosa, Cal., '97	0		NEWMAN, AV.	3	
P. angustifolia (species) AV.	21		Denton, Md., '97	0	Proterogynous.
Starkville, Miss., '97	0		Parry, N. J., '97	5	
Stillwater, Okla., '96	10		PIRAM,		
do. Lot II., '96	10		Denton, Md., '97	50	
do. '97	0		ROBINSON, AV.	12	
Manhattan, Kan., '96	0		Manhattan, Kan., '96	20	
Denton, Md., '97	25		do. '97	5	
Amherst, Mass., '96	0		Santa Rosa, Cal., '97	5	
do. '97	65		Lincoln, Neb., '97	0	
Agl. Coll., Mich., '97	14		Parry, N. J., '97	0	
Dublin, Ireland, '97	3		Madison, Wis., '94	38	
Biltmore, N. C., '97 (cultivated)	41		do. '96	29	
		[nous.	North Ferrisburgh, Vt., '97	0	
do. do. '97	83	Proterogy-	TRANSPARENT, AV.	44	
			College Sta., Tex., '97	8	
			Denison, Tex., '96	80	

MARIANNA GROUP.

Variety.	% Defective.	Remarks.	Variety.	% Defective.	Remarks.
DE CARADEUC,	40		MARIANNA, (concluded)		
MARIANNA, AVERAGE.	12		Madison, Wis., '94	38	
College Sta., Tex., '97	0		do. '96	100	
Starkville, Miss., '97	12		Amherst, Mass., '96	67	
Auburn, Ala., '97	0	Long styles.	do. '97	15	
Augusta, Ga., '97	5		North Ferrisburgh,		
Phœnix, Ariz., '97	10		Vt., '96	0	
Manhattan, Kan., '97	60		do. '97	0	
Blacksburg, Va., '97	0		Orono, Me., '96	33	Long styled.
State Coll., Pa., '97	50				

MISCELLANEOUS HYBRIDS.

Average defectiveness of pistils for the entire group 18.1 per cent.

Variety.	Parentage.	Source.	% Defective.
AMERICAN SURPRISE,	Botan × Robinson	L. Burbank.	0
GOLDEN,	do.	"	0
UNNAMED,	do.	"	0
UNNAMED,	Japan plum × Robinson	"	20
DORIS,	Myrobalan × Japan plum	"	0
UNNAMED,	Apricot × Japan plum	"	0
UNNAMED,	Almond × Japan plum	"	20
UNNAMED,	Japan plum × Apricot	"	0
UNNAMED,	Languedoc Almond × Burbank	"	0
UNNAMED,	Pissard's plum × Kelsey	"	5
UNNAMED,	*P. simonii* × Burbank	"	0
UNNAMED,	Japan plum × *P. subcordata*	"	35
UNNAMED,	Cherry × Japan plum	"	10
UNNAMED,	"Apetalous plum" × Apricot	"	100
MARYLAND,	*P. watsoni* × *P. besseyi*	J. W. Kerr.	0
MULE,	Wildgoose × Peach	"	100

MISCELLANEOUS SPECIES (PLUMS AND CHERRIES.)

Species.	% Defective.	Species.	% Defective.
Prunus gravesii Small New London, Conn., '97	39	*Prunus insititia* Linn, Copenhagen, Den., '97	0
P. serrulata Lindley Edinburgh, Scotland, '97	5	*P. subcordata* Benth., Santa Rosa, Cal., '97	0
P. tomentosa Thumb, Santa Rosa, Cal., '97	0	*P. spinosa*, Copenhagen, Den., '97	12
P. umbellata Ell., Lake City, Fla., 97	52	*P. simonii* Carr, AV. Denison, Tex., '97	6 12
P. maritima Wang, AV. Santa Rosa, Cal., '97	4 0	Santa Rosa, Cal., '97	0
Denton, Md., '97	9	*P. besseyi* Bailey, AV. Burlington, Vt., '96	22 45
P. avium Linn, AV. Edinburgh, Scotland, '97	1 0	do. '97	0
Copenhagen, Den., '97	3	*P. pumila* Linn, AV. St. Louis, Mo., '96	31 60
P. avium flore pleno, Edinburgh, Scotland, '97	100	Amherst, Mass., '96	60
P. pennsylvanica Linn., AV.	0	Burlington, Vt., '96 Copenhagen, Den., '97	0 6
Milton, Vt., '96	0	*P. caroliniana* Aiton, AV. Lake City, Fla., '97	31 33
North Ferrisburgh, Vt., '97	0	Auburn, Ala., '97	0
P. virginiana Linn., AV. Burlington, Vt., '96	2 0	Starkville, Miss., '97	60
Copenhagen, Den., '97	5	*P. padus* Linn, AV. Edinburgh, Scotland, '97	0 0
P. serotina Ehrh., AV. St. Louis, Mo., '96	0 0	Copenhagen, Den., '97	0
Burlington, Vt., '96	0	*P. padus heterophylla*, Copenhagen, Den., '97	0

DAIRYING.

J. L. HILLS.

The care and feeding of dairy animals and the handling and manufacture of their products have been prominent features of the experimental work of this station during the past eight years. This policy was inaugurated as a matter of course in view of the importance of the dairy industry in Vermont farm operations, and it is expected to pursue the same in as vigorous and thorough a manner as is consistent with the time, means, equipment and force which are available.

The investigations completed since the issue of the last report may be grouped under the following headings:

I. Studies in Methods of Experimental Feeding Trials.
 1. Summary.
 2. Introduction.
 3. Statement of Methods and Details of Conduct of Tests.
 4. The Proper Length of Feeding Periods.
 (*a*) Effect of Varying Period Lengths upon Quantity of Product.
 (*b*) Effect of Varying Period Lengths upon Quality of Product.
 5. The Relative Feeding Value of Two Rations of Equal Balance.
 6. Experimental Error in Feeding Tests.
 7. Practical Conclusions of Economic Value.

II. Feeding Trials with Silages and Potatoes.
 1. Summary.
 2. Corn Silage vs. Silage made from Cow Peas and Soja Beans.
 3. Corn Silage vs. Potatoes.

III. The Effect of Food upon the Quality of Butter.
 1. Summary.
 2. Effect upon Butter.
 3. Effect upon Churning.

IV. Record of the Station Herd for 1895–96.

V. Miscellaneous Fodder Crops.

VI. Tests of Dairy Apparatus.

VII. Appendix, containing condensed data pertaining to Articles I and II.

Articles I, II and III are prefaced by summaries of the matter which follows in greater detail.

I. STUDIES IN METHODS OF EXPERIMENTAL FEEDING TRIALS.

1. SUMMARY.

The details given in the following thirty pages may be briefly summarized, under their respective reference numbers and heads, as follows:

2. Thirty-four cows were used in the feeding trials of the winter of 1896–97. These trials lasted 24 weeks, and were designed to determine so far as possible:

(*a*) What length of feeding period is most likely to give reliable results?

(*b*) What difference in production may be expected when rations are fed which contain as nearly as may be the same amounts of digestible nutrients, yet are made up to some extent of different materials?

(*c*) To how great an extent may errors, due to animal individuality or other causes, be considered to be inherent in feeding trials.

3. The feeding periods were of various lengths in the different tests, and the rations were quite different. Full records were made of weights of cows, fodder, milk, etc., and constant analytical check was kept upon the work.

4. *The Proper Length of Feeding Periods.* Six pounds daily of Atlas gluten meal were substituted for a like weight of half corn and half bran in a ration containing 8 pounds of grain together with hay and silage. Nutritive ratios averaged, Atlas ration, 1:6.6, corn and bran ration, 1:10.2. Sufficient digestible dry matter to meet the Wolff standard was eaten in each ration, but digestible protein was lacking, particularly in the corn and bran ration. These rations were fed to four sets of three cows each in 4, 6, 7, and 8-week periods.

Feeding periods four weeks long (ten days preliminary, eighteen days experimental) were found to give results in quantity of product similar in character and extent to those afforded by the use of periods of six, seven, and eight weeks' duration. A disproportionate or one-sided increase in the per cent. of fat, observed in 4-week periods when the Atlas ration was fed, was not found to occur when the longer periods were used. The milk given during the first one to three weeks of Atlas feeding was uniformly richer than that given on the same ration in the weeks succeeding. This result does not tend to increase one's confidence in the accuracy of the few authenticated observations on record indicating the possibility of influencing the fat content of milk by changes in feeding, particularly in view of the fact that in almost every case periods less than four weeks long were used.

The effect of the changes in feeding upon the quality of the milk obtained in the 4-week period is not large either way. Such as it is, it is discounted by the results obtained in longer periods. Hence the writer's faith in the 4-week period as a fairly reliable measure of the results which may be expected to follow practical feeding is not shaken, but, on the contrary, is strengthened, as a result of the present study. Longer periods will some-

times prove advisable, particularly where animals are plenty, and a long season of fairly uniform environmental and meteorological conditions is ahead. Overlong periods are inadvisable however, for in proportion as periods are lengthened, the opportunities for separate comparisons are curtailed. Further investigations in the same line are in view for the coming winter.

5. *The Relative Feeding Value of Two Rations of Equal Balance.* It has usually been found, when two rations of unequal balance (*i. e.* with different nutritive ratios and containing different amounts of digestible nutrients) are fed, that increased production accompanies the larger supply of protein. Does it follow, however, when the same amounts of each nutrient are fed in each ration but different feeding stuffs used, that production will be uniform? May not the cow do better on one ration than on the other, despite the dictum of the chemist's analysis and of digestion experiments?

Two rations, each containing hay, silage, corn and bran, one containing, in addition, cottonseed and linseed meals, the other, Atlas gluten meal, were fed to nine cows in order to test this point. The compositions of the materials were such that it was difficult to secure the exact end sought, and, as nearly as might be, equal amounts of protein were fed in each ration. Nutritive ratios averaged, cottonseed-linseed ration, 1 : 6.3, Atlas ration, 1 : 7.3. Sufficient digestible dry matter to meet the Wolff standard was eaten. Six per cent. more product was made upon the cottonseed-linseed ration, and the milk made thereon was a shade richer. The increase in quality covered all the milk ingredients, and was not disproportionate. The cottonseed-linseed ration made the greater product, yet contained the lesser amounts of total food. It was the narrower ration, however. The uniformity of the trend of results with each individual animal is thought to indicate that this difference, though slight, is really a food effect, and not due to experimental error.

6. *Experimental Error in Feeding Tests.* The question has been raised whether differences obtained in feeding various rations, one against another, are not frequently due to causes other than changing food, even where every precaution is taken to render all other conditions uniform. In order to test this point a repetition of previous experiments made at this station, consisting of the uniform feeding of cows for several months, was carried out with nine cows. Practically no change occurred in quantity or quality of product on a uniform ration. A pound of total dry matter produced as much milk, total solids and fat, at one time as at another, lactation stages being equalized. It is thought, however, that if but few animals are used, it is unsafe to claim that changes in product of less than 5 per cent. are of necessity due to changes in feeding.

7. *Practical Conclusions of Economic Value. Live Weight.* The cows gained in weight on the Atlas rations, and barely held their own on the corn and bran rations. Those fed on the cottonseed-linseed ration in the experimental error test gained considerably in weight.

Feeding Value of Rations. On the whole the three rations ranked as producers of milk and butter in the following order: first, cottonseed-linseed; second, Atlas; third, corn and bran. There was little to choose between the first two, both of which far surpassed the third.

Financial Aspect. At ruling prices of the past winter, and rating silage at $3 a ton, the milk and butter made from the Atlas and the corn and bran rations cost (for food) 77.8 and 84.7 cents per hundred, and 14.1 and 14.9 cents per pound respectively. The milk and butter made from the Atlas and the cottonseed-linseed rations cost (for food) 127.8 and 128.5 cents per hundred, and 20.1 and 20.0 cents per pound respectively. The high figures in the second case are due to the fact that the cows used in the latter test were strippers. The qualities of these various butters should be noted in this connection.* The very low prices at which corn and bran sold in 1896 are important factors in this result.

Fertilizing Values. The Atlas ration contained 29 and 22 per cent. and the cottonseed-linseed ration 16 per cent. greater fertilizing value than did the corn and bran ration. This increase is entirely due to the greater richness of the by-products in nitrogen.

2. INTRODUCTION.

Feeding experiments with various classes of farm animals have received a large share of the attention of experiment station investigators in this and other countries from the very outset of their work. Much thought, labor and expense have been spent upon these trials, and many important conclusions drawn from them. Most of this effort has been directed at the solution of specific questions rather than at the systematic investigation of the principles of animal nutrition. The determination of the relative food values of two rations or feeding stuffs or, perhaps, the comparative merits of different breeds of live stock, definite problems of obvious, practical, immediate importance, have taken precedence over the discovery of the more general truths of wider application which include the narrower and more empirical tests, and which would in a large measure make them unnecessary. Such tests seldom furnish material for generalization, their results are often contradictory, they do little to advance our knowledge of fundamentals, and they are frequently so uncertain in their outcome as to make it unsafe to hazard predictions regarding the effects of given rations and conditions upon production.

This trend in feeding experimentation towards the simpler and more specific problems is quite natural and the value of the results obtained is doubtless considerable. The question may well be raised, however, whether as large returns have followed as might reasonably have been expected from equal outlay upon research of a less superficial character.

*See the article entitled "The Effect of Food upon the Quality of Butter" further along in this volume.

The lack of agreement as to methods of experimentation as well as the difficulties hedging about the accurate management of even a simple feeding trial have been prime causes for the surface nature of the majority of feeding tests. Hardly does a convention of station workers meet that the matter of closer co-operation and greater uniformity in methods of conducting feeding experiments is not broached. The animal, its ration and environment are all of the utmost importance and need to be carefully considered in formulating the plan of a feeding trial. Yet there are many matters touching each of these, the effects of which are still undetermined. Among the moot-points the following may be instanced, and the list is far from exhaustive:

1. *Animal.* How many animals shall be used? Of what age? Of what weights? How long shall feeding be conducted? Shall sets alternate on different feeds or be retained on one? How long feeding periods shall be used? How shall individuality be gauged?

2. *Ration.* Are the present digestion co-efficients safe to use with all animals? How may the variable effect upon production of the same amount of nutrients with different animals be properly measured? What is the residual effect of rations fed in previous periods upon the production of later periods? What value shall be given in milk making to the nutrients stored up in the body and drawn upon, unevenly perhaps, during various changes of feed? How much variation may be looked for in the results, even when no change in ration occurs? What effect has palatability upon production? What is the relation to milk making of the amount of water consumed in drink and food? What is the effect of mechanically preparing food?

3. *Environment and Physical Conditions.* What effects upon production follow extremes of heat and cold, rain and sun, drought, insect attacks, etc.? Have ventilation or its lack, sunlight or shade, confinement or relative freedom, exposure or protection, cleanliness or filth, nervous excitement or quiet, measurable effects upon production?

These prefatory remarks are not meant as an indictment of feeding tests in general, nor should they be construed as casting doubt upon the value of the results attained thus far by their use. The writer deems it advisable, however, to make these statements, trite though they are, to explain the abandonment at this station, for a while at least, of feeding experiments designed to test definite feeding stuffs, and the substitution therefor of trials, the results of which it is hoped will aid in the solution of some of the vexed questions underlying *methods of experimentation in feeding milch cows.* It may happen that in connection with these tests more or less information will be obtained touching the food values of various materials; if so it will be published. It is expected, however, to make the search for such data secondary and subordinate to the main object.

The feeding experiments of the past winter were designed to shed light upon the following points:

(*a*) *What length of feeding period is most likely to give reliable results?*

(*b*) *What variations in production are to be expected from different rations containing essentially the same amounts of the various nutrients?*

(*c*) *What is the extent of the probable error inherent in feeding experiments due to the individuality of the animals used, or to other causes?*

The feeding trials were respectively known as the "period length," "equal balance," and "experimental error" tests, and are so referred to hereafter.

3. STATEMENT OF METHODS AND DETAILS OF CONDUCT OF TESTS.

The "period length" test was made with fifteen cows, the "equal balance" test with nine, and the "experimental error" test with ten cows.

It was to be expected that more or less trouble from sickness and other causes would occur when so large a number of cows were under experiment, especially when we consider the frequent and radical changes in feeding occurring from time to time. Jessie (period length) had to be withdrawn during the first period because of sickness. Cressy (period length) refused to eat Atlas gluten meal in any considerable quantity, thus rendering results in her case of no value. Fanny (period length) was off her feed at one time. Idarella (experimental error) was rather dainty in her eating and refused considerable amounts of food.

An unfortunate mistake in feeding rendered useless the records of the cows Flora and Flox (period length). As these cows were joined with Jessie (sick) in the 5-week period test, no records whatever for that particular period length are available. The cows in the "equal balance" test were allowed to run two weeks longer upon the ration fed during the second period than was intended, this error being caused by a misunderstanding. It should be said, moreover, that the herd has seldom if ever been in such poor condition for the purposes of feeding experiments as it was during the past fall and winter, owing to persistent failure to breed. The selections were therefore in several cases far from what could be wished. It is thought, however, notwithstanding these sins of omission and commission, bovine as well as human, that the results and the deductions therefrom are trustworthy. A careful study of previous records, extending over nearly three years with some of the animals, and of their ages, time of calving, etc., preceded their selection for the various experiments. The "period length" test received preference in the choice, followed by the "equal balance" and the "experimental error" tests.

DETAILS OF FEEDING.

The feeding periods in the "period length" test were 4, 5, 6, 7 and 8 weeks long; in the "equal balance" test, for reasons already stated, they were of uneven length; in the experimental error test they were four weeks long. The first third of each feeding period was considered preliminary and non-experimental; yet full feeding and milk records were kept in the same manner as during the experimental portions of the periods. The results obtained and the conclusions drawn are based only upon the experimental [illegible]. In all cases of change of rations, from three to five days of the preliminary portion of the new period was consumed in getting the animal fully upon her new diet.

The cows were fed twice a day, watered twice, and turned out in the yard once a day until February 1, and twice a day after that date, being out about a half-hour daily. Hay and grain were fed first morning and evening, and after these were eaten each cow received as much silage (in a few cases corn fodder) as she would eat. The fodder and feed given each cow were weighed and the orts were weighed back daily, and their general nature noted. The following statement shows the general daily feeding plan:

"*Period length*" *test*. Hay, 10 pounds; silage ad libitum; either 8 pounds equal weights corn meal and wheat bran, or 8 pounds of grain, consisting of 6 parts Atlas gluten meal, and 1 part each of corn meal and wheat bran (by weight); 5 parts of Atlas gluten meal and 1½ parts each of corn and bran were fed Effie and Dora instead of the stronger Atlas ration.

"*Equal balance*" *test*. Hay, 10 pounds; silage ad libitum; either 8 pounds of mixed feed No. 1, or 9 pounds of mixed feed No. 2. No. 1 was made up (by weight) of 6 parts wheat bran, 4 parts corn meal, 3 parts cottonseed meal, 3 parts linseed meal; No. 2 was made up (by weight) of 6 parts wheat bran, 4 parts corn meal, 8 parts Atlas gluten meal.

"*Experimental error*" *test*. Hay, 6 pounds; corn fodder ad libitum; beets, 6 pounds; mixed feed No. 1, 6 pounds (Salida, Daisy, Helena). Hay, 10 pounds; ensilage ad libitum; roots, 6 pounds; mixed feed No. 1, 8 pounds (Jessaline, Rowena, Bess). Hay, 8 pounds; corn fodder ad libitum; roots, 6 pounds; mixed feed No. 1, 8 pounds (Regina, Golden Rod, Idarella, Besette).

A comparison of the Wolff standard for digestible dry matter with the amounts of the same eaten shows that the cows usually ate more than is called for by the standard. Effie ate barely the equivalent of the standard, and some of the "experimental error" cows in the last periods ran a little short. This was not from lack of food, however, as they left fodder in their mangers.

WEIGHTS OF COWS.

All cows under test were weighed the first three days of the opening period and on the last three days of all periods. The averages are given in the appendix. All the cows increased in weight during the winter. Brow-

nie, Jeannie, Eulalie, Golden Rod and Besette were heavy with calf at the close of the tests.

The cows in the "period length" test made much larger gains in weight on the Atlas than on the corn and bran ration. There are twenty-three average weight records on each ration. In five cases the weight after feeding for from four to eight weeks on the corn and bran ration was less by thirty pounds or more than it was at the end of the previous period upon the Atlas ration, and in seven other cases essentially no change occurred. In but half the observations were material gains in weight found following the corn and bran feeding. In twenty out of twenty-three cases decided gains in weight occurred coincident with the Atlas feeding. Less marked results but of a similar nature were found in last year's tests in a ration containing smaller amounts of Atlas gluten meal.

It is impossible to make as clear-cut a comparison in the "equal balance" as in the "period length" test in the matter of the relation of increase of weight to ration fed, owing to the variation in period lengths. No material difference could be discovered in favor of either ration.

The cows in the "experimental error" test made less increase in the first period than they did later, but made fairly even gains throughout the other periods.

BARN TEMPERATURES.

The temperature of the cow stable was taken daily at 5 A. M., 12 M., and 6 P. M. The exposed location of the station barn causes decided fluctuations in the temperature of the cow stable during the winter, notwithstanding the comparatively large number of animals housed therein.

The average barn temperatures, morning, noon and night, during each period and the per cent. of the entire number of observations within 3° F. of the mean of each period are tabulated in the appendix. Variations of 5° or more from average of the period occurred as follows:

Nov. 27, 13° warm (this, the most marked change of all, took place in the non-experimental portion of the first feeding period of all the cows); Dec. 3-4, 6° cold; Dec. 6, 3° warm and 9° rise in 48 hours; Jan. 3-6, 9° warmer than average preceding, followed by temperatures somewhat colder than average; Jan. 20-21, 8° cold; March 1, 39°, the coldest barn temperature of the winter, being 9° below average; April 5-7, also April 16-17, 5° warm; April 23-26, 62°—68°, 9° warm; May 6-8, 7° cold.

A careful study was made of the yields and qualities given on these dates. Alterations in the yield of milk seem to have coincided with the more decided temperature variations on only four out of twelve times.

Dec. 3, 6 per cent. decrease; barn temperature 6° low of average.

Dec. 6, 3 per cent. increase; barn temperature rose 9° in 24 hours.

Jan. 7-8, 6 per cent. decrease; cold weather following a warm spell.

March 1, 2 per cent. decrease; coldest barn temperature of winter.

No definite relation between temperature fluctuations and quality changes could be traced. One hundred and six comparisons showed 39 quality changes of greater or less extent inverse in their direction to the thermometric variation, 29 in the same direction, while 38 times no change whatever occurred. It is quite certain that these few changes, mostly slight, had but little effect in modifying the period averages, each of which for each animal is based on the analyses of from four to nine composite samples of milk. While a uniform barn temperature would have been highly desirable, it is thought these comparisons show that, as a matter of fact, the temperature fluctuations had little if any effect upon the ultimate outcome of the present experiments. It should be noted, moreover, that since all the cows were housed together, these effects, if any, might be expected to be uniformly exerted upon all. It should be remembered also, in this connection, that all the cows were turned out daily for from twenty to forty minutes.

COWS USED AND PERIOD DATES.

The following tables indicate the period-dates and the cows in use with the nature of the grain feed eaten during each period. The cows whose names are italicised are registered Ayrshires, the black faced letters indicate registered Jerseys, while the names given in ordinary type are those of high grade Jerseys.

DATES OF FEEDING PERIODS.

	Four-Week Period and Experimental Error.	Rations of Equal Balance.	Six-Week Period.	Seven-Week Period.	Eight-Week Period.
I. Prelim..	Nov. 25-Dec. 5	Nov. 25-Dec. 7	Nov. 25-Dec. 10	Nov. 25-Dec. 12	Nov. 25-Dec. 15
Exper..	Dec. 5-23	Dec. 7-30	Dec. 10-Jan. 6	Dec. 12-Jan. 13	Dec. 15-Jan. 20
II. Prelim..	Dec. 23-Jan. 2	Dec. 30-Jan. 11	Jan. 6-21	Jan. 13-30	Jan. 20-Feb. 9
Exper..	Jan. 2-20	Jan. 11-Feb. 17	Jan. 21-Feb. 17	Jan. 30-Mch. 3	Feb 9-Mch. 17
III. Prelim..	Jan. 20-30	Feb. 17-Mch. 1	Feb. 17-Mch. 4	Mch. 3-20	Mch. 17-Apl. 6
Exper..	Jan. 30-Feb. 17	Mch 1-24	Mch. 4-31	Mch. 20-Apl. 21	Apl. 6-May 19
IV. Prelim..	Feb. 17-27	Mch. 24-Apl. 3	Mch. 31-Apl. 15		
Exper..	Feb. 27-Mch. 17	Apl. 3-21	Apl. 15-May 12		
V. Prelim..	Mch. 17-27	Apl. 21-May 1			
Exper..	Mch. 27-Apl. 14	May 1-19			
VI. Prelim..	Apl. 14-24				
Exper..	Apl. 24-May 12				

MILKING AND MILK SAMPLES.

Every milking was weighed. The milk of each cow in the "period length" test was sampled at every milking in both the preliminary and the experimental portions of each period. Samples were taken in the other tests throughout the first and last thirds of the experimental portions of the periods, and the quality of the milk given in the intervening third was assumed to be the average of that given during the other experimental portions of the period. Composite samples representing six or eight milkings were taken and analyzed by the Babcock centrifugal method for fat, while the Quevenne lactometer, the Hehner and Richmond formula ($T=1.2\ F + (L \div 4) + 0.14$), the fat percentage, and the milk slide-rule furnished the total solids.

COWS USED IN THE EXPERIMENTS, AND NATURE OF GRAIN RATIONS FED EACH PERIOD.

"Period Length."	Approximate Age, Nov. 1, 1896.	Calved 1896.	Served 1897.	Period No. I.	Period No. II.	Period No. III.	Period No. IV.	Period No. V.	Period No. VI.
FOUR WEEK.									
Acme.	7	Sept. 19.	April 1.	Atlas meal.	Corn & bran.	Atlas meal.	Corn & bran.	Atlas meal.	Corn & bran.
Effie.	10	July 9.*	April 24.	Atlas meal.	Corn & bran.	Atlas meal.	Corn & bran.	Atlas meal.	Corn & bran.
Dora.	7	Sept. 21.	Dec. 31.	Corn & bran.	Atlas meal.	Corn & bran.	Atlas meal.	Corn & bran.	Atlas meal.
SIX WEEK.									
Atalanta.	7	Sept. 13.	Feb. 15.	Atlas meal.	Corn & bran.	Atlas meal.	Corn & bran.		
Goldie.	10	June 29.		Atlas meal.	Corn & bran.	Atlas meal.	Corn & bran.		
Fanny.	7	Sept. 24.	Farrow.	Corn & bran.	Atlas meal.	Corn & bran.	Atlas meal.		
SEVEN WEEK.									
Maizie.	10	Nov. 14.	April 14	Corn & bran.	Atlas meal.	Corn & bran.			
Kittie.	7	Aug. 25.	Farrow.	Atlas meal.	Corn & bran.	Atlas meal.			
EIGHT WEEK.									
Nancy B.	9	Aug. 29.	Feb. 20.	Atlas meal.	Corn & bran.	Atlas meal.			
Marjory.	7	June 12.	Dec. 17.‡	Atlas meal.	Corn & bran.	Atlas meal.			
Minta Bella.	5	M. Jan.	April 11.	Corn & bran.	Atlas meal.	Corn & bran.			
"EQUAL BALANCE."									
Red Top.	7	Oct. 28.	April 26.	Cottonseed, Linseed, etc.	Atlas gluten meal.	Cottonseed, Linseed, etc.	Atlas gluten meal.	Cotton-seed, Linseed, etc.	
Max Belle.	4	M. Jan.	Mar. 18.						
Bettie	8		Farrow.						
Brownie.	7		Sept. 6.						
Clover.	9	Jun. 19*	Jan. 4.						
Jeannie.	7		Aug. 4.						
Eulalie.	7	Farrow.	Aug. 25.						
Kinkora.	7	Farrow.	Farrow.						
Julia.	7	Farrow.	Feb. 23.						
"EXPERIMENTAL ERROR."									
Salida.	2	May 21.	Feb. 13.	Fed the same from November 25—May 12 in order to determine the extent of experimental error.					
Helena.	2	May 22.	Dec. 25.						
Daisy.	2	Jan. 19.	Feb. 13.						
Regina.	7	Jan. 16†	Farrow.	Fed as above January 20—May 12.					
Rowena.	5	Farrow.	Farrow.	" " November 25—February 17.					
Bess.	10	March 6.	June 7.	" " " "					
Golden Rod.	5	Jan. 6.	July 1.	" " " "					
Idarella.	6	Farrow.	Farrow.	" " " "					
Besette.	5	Lt. Jan.	July 1.	" " " "					

*Aborted.

†1897. ‡1896.

FODDERS AND FEEDS.

The fodders and feeds in use were sampled once a fortnight, 180 samples of "roughages" and 97 of grain feeds being taken, the former usually in quadruplicate at each sampling date. All samples were individually analyzed for their dry matter content and were then combined to make thirty-four composite samples for complete analysis. A table of analyses appears in the appendix; the averages are shown below.

AVERAGE ANALYSES OF FODDERS AND FEEDS IN USE.

Fodders and Feeds.	Original Substance.		Composition of Dry Matter.							
	Water.	Dry matter.	Crude ash.	Crude protein.	Crude fibre.	Nitrogen-free extract.	Ether extract.	Nitrogen.	Phosphoric acid.	Potash.
Silage	76.57	23.43	6.68	7.50	25.06	58.33	2.43	1.20	0.58	1.57
Corn fodder	38.00	62.00	6.24	7.16	28.16	56.26	2 18	1.15	0.43	1.34
Hay	12.75	87.25	6.71	7.60	31.18	51.96	2.55	1.22	0.45	1.83
Beets	83.85	16.15	17.41	10.26	6.40	65 36	0.57	1.65	0.62	2.74
Carrots	86.74	13.26	21.76	8.84	9.84	58.62	1 04	1.41	0.53	3.69
Atlas gluten meal, 1st lot	7.00	93.00	2.06	36.61	11.82	36.22	13.29	5.87	0.64	0.09
" " " 2nd lot	6.54	93.46	2.16	34.06	12.28	38.83	12.67	5.45	0.62	0.12
Corn meal and wheat bran (equal parts)	9.96	90.04	3.91	14.42	5.40	71.15	5.12	2.31	1.19	0.95
Mixed feed No. 1*	8.70	91.3	5.25	25.56	7.24	55.21	6.74	4.09	1.18	1.43
" " No. 2†	8.27	91.73	3 53	23.76	9.76	54.83	8.12	3.81	1.15	0.81

*Six parts wheat bran, four parts corn meal, three parts each of cottonseed meal and linseed meal (by weight.)

†Six parts wheat bran, four parts corn meal, eight parts Atlas gluten meal (by weight).

The digestive co-efficients used in calculating digestible nutrients and nutritive ratios were taken from the tables of digestibility of American feeding stuffs as published by Lindsey* and by Jordan†. No complete analyses of the separate ingredients of the mixed feeds were made except of the Atlas gluten meal. Samples of the corn meal, bran, cottonseed and linseed meals were taken at fortnightly intervals and their moisture contents determined. The dry matters of the mixtures as actually obtained and those of the several ingredients calculated to the various formulas of the mixed foods checked within the limits of analytical error.

In order to determine the digestive co-efficients of the mixed feeds, analyses of each material entering into their composition is necessary. These were not at hand, so the averages as given by Jenkins and Winton‡ in their compilation of analyses of American feeding stuffs were used, calculated to the observed moisture contents of the materials which were fed. A com-

*Rpt. Mass. (Hatch) Exp. Sta., 9 (1896), pp. 158-170.

†Exp. Sta. Record, 6 (1894-95), pp. 5-8.

‡Bul. Office Exp. Sta., 11 (1892), pp. 16-19.

parison of the actual analyses of the mixed feeds used with these averages calculated to the formulas of the three feeds shows that no appreciable error was introduced by using these averages for the purpose stated.* The effect of one feed upon the digestion of another in the mixture and the result thereof upon the digestion coefficients is very uncertain and is possibly considerable, but since it cannot be stated, even approximately, it is for the purposes of this experiment ignored. Tables showing digestion coefficients and pounds of digestible ingredients per 100 pounds of dry matter are given in the appendix.

RECORDS OF THE FEEDING TESTS.

Never before have so many cows been included in feeding experiments at one time at this station as during the winter of 1896-97. The experimental feeding and milking of thirty-four cows involved a vast amount of work, necessitating over 46,000 barn weights. Analyses were made of 276 samples of fodders and feeds for dry matter, of 34 similar materials for the various ingredients (complete analyses), and of over 1200 composite milk samples for fat and specific gravity. And, finally, there were many hundreds of hours of work spent in collecting and calculating the records of the tests in preparation for publication which do not appear upon the surface. All the mathematical work in connection with this, as with all other similar work published by the station, is done in duplicate, is accomplished as far as possible with the aid of calculating instruments, and is believed to be absolutely accurate.

Our custom of publishing condensed data in an appendix, where it is of ready reference yet does not cumber the reading matter, has been followed in the present instance, all figures except those absolutely necessary to the explanation of the text being relegated to the rear. Even the briefest possible condensation of the data uses up a large amount of space; the detailed records would "fill a book." This matter appears in the appendix (Article VII of "Dairying") under the following headings:

I. Weights of cows.

II. Average barn temperatures, with ranges, and percentages of uniformity, etc.

III. Analyses of fodders and feeds; digestion coefficients, pounds of digestible ingredients in fodders and feeds, etc.

IV. Feeding records of the individual cows.

V. Records showing, for each individual cow, the production of milk, total solids and fat, the quality of the milk, and the production per unit of dry matter in the total ration and in its experimental portion.

VI. "Difference tables," (*a*) Period length, (*b*) Equal balance, (*c*) Experimental error. Showing differences (in experimental feeding) between the average of the results of two periods on one ration and those actually obtained with another ration in the intervening period.

*See tabulated comparisons in VII. Appendix II.

4. THE PROPER LENGTH OF FEEDING PERIODS.

One of the details of feeding trials with milch cows regarding which there is much variance in practice and apparently in opinion concerns the length of the feeding periods. Reference to the publications of experiment stations in this and other countries discloses entire lack of uniformity touching this matter, not only among different investigators but also in the work of single stations. Our own station cannot claim itself holier in this respect than its sister institutions, since prior to 1892 its feeding tests were divided into periods of three, two, and even one week in length, while subsequent to that time 4-week periods (ten days preliminary, eighteen, experimental) have been in use. The results obtained with periods of the latter length have been as a rule clear-cut and apparently satisfactory, yet this division of time is purely arbitrary, and is based upon judgment rather than upon experimental data. Indeed so far as the writer can discover by thorough search and through consultation with others, no tests have been made showing what is and what is not a reliable period length. The short period of one or two weeks is clearly to be condemned as likely to furnish erroneous results, since the animal can hardly be said to have begun to feel the effects of the change in ration when the period is over. While such results are surely untrustworthy it is not yet clear whether three or four weeks or more are necessary to furnish reliable data. If a certain result follows the feeding of a given ration for one month, is the same outcome, similar in character and in extent, to be expected during the second and following months? May not the changes in production which follow an alteration in the ration be but temporary effects, which disappear or at least are greatly lessened under the conditions of prolonged, regular, practical feeding? Since these questions cannot be answered with certainty, it would seem to be the part of wisdom to determine as far as possible the proper length of feeding periods before making further and perhaps misleading trials.

A series of feeding tests, carried out during the winter of 1896-97, is here reported as a contribution to the solution of this problem. Fifteen cows were divided into five sets of three each and were fed two rations in alternating periods of five different lengths. Sets 4, 5, 6, 7, and 8 respectively were fed for 6, 5, 4, 3 and 3 periods, each period being respectively 4, 5, 6, 7 and 8 weeks long. Set 4 shuttled back and forth during twenty-four weeks in six periods while set 8 in the same time covered but three periods, each, however, twice as long as those in which set 4 was fed. Similarly sets 5, 6 and 7 were fed five periods each five weeks long, four periods each six weeks long, and three periods each seven weeks long. Each set was fed the same two rations, the cows were stabled together and in every respect handled similarly save as regards the length of the feeding period for each ration. The periods were divided into preliminary and experimental portions

as follows: 4-week periods, 10 and 18 days; 5-week periods, 12 and 23 days; 6-week periods, 15 and 27 days; 7-week periods, 18 and 31 days; 8-week periods 20 and 36 days respectively. Weights, records, samples, and analyses were made with the same care and thoroughness in the preliminary as in the experimental portions. Unfortunately a serious mistake was made about the middle of the winter in the feeding of two of the three cows of set 5, which rendered the results worthless. The third cow in this set went off her feed early in the test so that no data whatever were obtained for the 5-week period. This makes a serious and greatly regretted break in the series.

It seemed advisable to adopt as the main ration the hay, silage, corn meal and wheat bran combination, which had been used for six years at the station as a standard of comparison in feeding trials, and to incorporate, as a prominent ingredient of the other ration, and in the place of as large a part of the corn meal and wheat bran as was deemed safe, some material which past experience had shown to exert a marked effect upon production during periods four weeks long. If this latter ration produced similar results during the longer periods, the natural inference would be that the effect formerly observed was not temporary, and that four weeks was a safe period length to use in testing that particular ration. If, however, the results were altered in either direction, and in proportion as this difference increased, doubt would be cast upon the validity of results secured with periods four weeks or less in length.

A careful survey of the feeding work of this and other stations resulted in the selection of Atlas gluten meal* as the ingredient to insert into the standard combination to form the experimental ration in this set of feeding trials. This feeding stuff was used at this station in its feeding trials of the winter of 1895-96, with more pronounced results than had been obtained with other feeds except, perhaps, with cream gluten meal. It produced, when fed to 6 cows in 4-week periods, an eighth more milk and a sixth more butter than did a corn and bran ration, slightly bettered the milk (0.20 per cent. fat), and narrowed the ratio of fat to solids not fat (corn and bran ration, 1:1.93; Atlas gluten meal ration, 1:1.83), thus making that rarely observed change in the quality of milk, slight though it was, namely, a disproportion-

*"Atlas gluten meal strictly speaking, is misnamed. It is not, in the usual acceptance of the term, a gluten meal, but is a by-product obtained in the process of making alcohol from corn or grain by distillation. The starch of the grain is converted into sugar by the action of the malt which is added. Part of this sugar is then transformed, by fermentation, into alcohol, which is removed by distillation. The hull, gluten, germ, with more or less unaltered starch and some sugar, together with the malt sprouts, remain behind, and after drying compose the feed. It is made by the Atlas Distilling Co., Peoria, Ill, and was sold in this vicinity in the fall and winter of 1895 at $16 a ton, being probably the cheapest form of protein upon the market. Atlas gluten meal is very rich in both protein and fat, has a pleasant, clean, nutty smell, and is usually much relished by cows." (Rpt. Vt. Exp. Sta., 9 (1895), pp. 218-219.)

ate increase in the fatty portion of the total solids.* It had likewise been fed experimentally by Lindsey† in 17-day periods to 4 cows in comparison with Chicago gluten meal and no change in quantity or quality of the product observed.

In our experience as well as in that of other feeders it has proved to be much less likely to throw a cow off her feed than the glutens, properly so called, and it therefore could be fed with safety in larger quantities than could the cream or King glutens, both of which, when fed in 4-week periods at this station, had been observed to have a slight tendency to increase disproportionately the fat in milk and otherwise to have a pronounced effect upon milk production.‡

Atlas gluten meal is not as even in quality as might be wished. Lindsey§ has pointed out this fault and has called attention to the wisdom of buying subject to analysis. Two different lots were used in the tests now under consideration, the first being but slightly inferior to that used last year, while the second was considerably poorer, as is shown by the following average protein and fat percentages: 1895-96, protein, 38.15, fat, 14.27; 1896-97, 1st lot, protein, 36.61, fat, 13.29; 2nd lot, protein, 34.06, fat, 12.67.

The two rations used were quite different in their nutritive ratios. The corn and bran ration was pre-eminently "wide," varying with the different cows and periods from 1 : 9.8 to 1 : 10.5 and averaging 1 : 10.2. The Atlas ration, while by no means "narrow," was much narrower than its competitor, varying from 1 : 6.1 to 1 : 7.0 and averaging 1 : 6.6.‖ These variations were mainly caused by the greater or less freedom with which silage was eaten. This wide difference in balance was intentional and highly desirable as it tended to make the results more emphatic. Neither of the above rations correspond with the Wolff standard with its nutritive ratio of 1 : 5.4. It has been pointed out already that all the cows ate as much, and most of them more digestible dry matter than is called for by this standard. They always ate more than the standard amount of digestible carbohydrates, and when on the Atlas ration, a sufficiency of digestible protein was eaten to satisfy the German requirements. When put upon corn and bran, however, the amount of digestible protein eaten was seldom more than two-thirds that of the standard. In connection with this point the effect of the two rations upon the live weight should be recalled. The diversion of some of the Atlas protein to the manufacture of live weight and the use of body protein for milk making during corn and bran periods is possible, although by no means proved.

*Rpt. Vt. Exp. Sta., 9 (1895), pp. 222-223.

†Rpt. Mass. (Hatch) Exp. Sta. 8 (1895), pp. 231-232.

‡Rpt. Vt. Exp. Sta., 6 (1892), pp. 146-149, 152; Buls. 33 (1892); 48 (1894), pp. 72-75, 77-78.

§Mass. Bd. Agr., Crop Rpt., Bul. 6 (1896) p. 38.

‖Effie and Dora, fed a mixture containing a little less Atlas meal, ate a ration the nutritive ratio of which averaged 1 : 7.2.

(*a*) EFFECT OF VARYING PERIOD LENGTHS UPON QUANTITY OF PRODUCT.

The following tables are taken from the condensed records printed in the appendix. The results of last year's tests are likewise included.

The first table shows the increase (expressed as percentages, total =100) in milk, total solids, and fat given, and of products per 100 pounds of dry matter, when an Atlas gluten meal ration (nutritive ratio 1 : 6.2) replaced a corn meal and wheat bran ration (nutritive ratio 1 : 10.2) for different lengths of time.

SUMMARY OF DIFFERENCE TABLES VI. (*a*) (APPENDIX.)

Length of Period in Weeks.	Days in Experimental Portion of Period.	Number of Cows Used.	Total Dry Matter.	Milk.	Total Solids.	Fat.	PRODUCT PER 100 POUNDS OF DRY MATTER.		
							Milk.	Total Solids.	Fat.
4	18	6	+3	+16	+18	+20	+12	+13	+15
4	18	3	−1	+11	+11	+15	+12	+12	+15
6	27	3	+2	+11	+11	+14	+ 9	+ 9	+10
7	32	1	−3	+ 3	+ 3	+ 5	+ 6	+ 6	+ 6
8	36	1	−2	+ 5	+ 4	+ 4	+ 7	+ 9	+ 8

The second table shows the decrease (expressed as percentages, total=100) in milk, total solids, and fat given, and of products per 100 pounds of dry matter, when a corn meal and wheat bran ration (nutritive ratio 1 : 10.2) replaced an Atlas gluten meal ration (nutritive ratio 1 : 6.6) for different lengths of time.

SUMMARY OF DIFFERENCE TABLES VI. (*a*) (APPENDIX.)

Length of Period in Weeks.	Days in Experimental Portion of Period.	Number of Cows Used.	Total Dry Matter.	Milk.	Total Solids.	Fat.	PRODUCT PER 100 POUNDS OF DRY MATTER.		
							Milk.	Total Solids.	Fat.
4	18	6	−4	−11	−11	−15	− 6	− 7	−11
4	18	3	+2	−13	−12	−14	−15	−14	−16
6	27	3	+1	−10	− 8	− 8	−10	− 9	− 9
7	32	1	0	−20	−16	−15	−20	−16	−16
8	36	2	0	−17	−14	−12	−16	−16	−13

The third table shows the increase (expressed as percentages, total=100) in milk, total solids, and fat given, and of products per 100 pounds of dry matter, when an Atlas gluten meal ration (nutritive ratio 1 : 6.2) replaced a corn meal and wheat bran ration (nutritive ratio 1 : 10.2) for different lengths of time.

[From comparative results of from 64 to 270 days' feeding; the showing made is similar to that of the first table but the results are arrived at in a different manner as will be seen on reference to the full tables.]

SUMMARY OF DIFFERENCE TABLES VI. (*a*) (APPENDIX.)

Length of Period in Weeks.	Days in Experimental Portion of Periods.	Number of Cows Used.	Total Dry Matter.	Milk.	Total Solids.	Fat.	PRODUCT PER 100 POUNDS OF DRY MATTER.		
							Milk.	Total Solids.	Fat.
4	270	6	+3	+15	+16	+19	+10	+11	+14
4	216	3	−1	+13	+12	+16	+14	+14	+17
6	162	3	0	+11	+10	+11	+10	+ 9	+10
7	64	3	−1	+10	+ 9	+10	+12	+11	+11
8	112	3	−1	+16	+13	+11	+16	+14	+12

These tables speak for themselves both as regards the matter of period lengths and the food value of Atlas gluten meal. The aggregations of plus marks in the first and third and of minus marks in the second table are eloquent on the latter point. The results appear clear-cut also in the matter of proper period lengths. It seems safe to assert that *in these trials, results essentially similar in character and extent were obtained when the Atlas ration was fed in periods from 6 to 8 weeks long as had been observed when it was fed for but 4 weeks. In other words, in this particular comparison, which it will be recollected is between a "medium" and a "wide" ration, feeding periods four weeks long gave trustworthy results as regards quantity changes. This deduction applies to the yield of milk alone and not to its quality. The effect of the Atlas ration upon the quality of the milk is considered under the next heading.*

While generalizations from a single experiment are very unsafe, the presumption may be hazarded that a similar period length would afford accurate results with any two rations as widely apart in their balances as were those used in the trials now under discussion. It is expected to test the same point on rations less widely different in their nutritive ratios during the coming winter.

(*b*) EFFECT OF VARYING PERIOD LENGTHS UPON QUALITY OF PRODUCT.

What effect had the extension of the feeding period upon the *quality* of the milk? Did it alter as a result of the wide change in the relative proportions of digestible nitrogenous and non-nitrogenous nutrients?

Before answering these queries it may not be amiss to discuss briefly the present status of the question of the influence of food upon the quality of milk (*i. e.* its per cent. of fat and the proportionate relation of the per-cent. of fat to that of the solids not fat).

THE EFFECT OF A CHANGE OF RATION UPON THE QUALITY OF MILK.

It has been the general belief of dairymen that the per cent. of fat in milk might be changed by modifications in feeding, that, in common parlance, they could "feed fat into milk." This belief has not stood the test of careful experiment and is being abandoned by many of its former advocates. Yet no later than the winter of 1896–97, a New England experiment station director (not the writer), having clearly stated the result of research upon this point before the Vermont Dairymen's Association, found a large proportion of his hearers firmly convinced that no matter what careful experiments the world over had indicated, they at any rate could increase the richness of milk by feeding.

This difference of opinion between investigators and practical dairymen is more apparent than real, and due largely to misunderstanding. For either to question the sincerity of the other were absurd. It is doubtful, however, whether the dairyman in his consideration of the subject gives due weight to the provisos and the limitations with which experimenters surround their statements.

The writer believes the position of those who regard the question from the standpoint of experimental research to be essentially this: That breeding, individuality, and, sometimes, environment determine the quality of a cow's milk, and that its fat percentage, and particularly the relation of the fat percentage to that of the solids not fat, is not influenced materially by feeding changes, provided that plentiful supplies of wholesome, nutritious foods are given in well-balanced rations. Quality changes may follow decided variations in the amounts of nutrients eaten, or result from the use of ill balanced or unpalatable rations; yet when such changes do occur they are usually comparatively slight in amount, and are much more likely to affect all the solids proportionately than to alter disproportionately the fat percentage. Radical changes from wide to narrow rations have sometimes been found to cause richer milk yields, but the enrichment has usually extended to all the solid ingredients, and not been confined to the fat alone. The fluctuations occurring from day to day, frequently extreme in amount, and due to causes more or less obscure, occur on uniform as well as upon varying rations, and do not enter into the question now under consideration. These variations sometimes coincide with feeding changes, but are not of necessity related thereto. In short, variations in feeding, unless extreme, affect quantity often but quality seldom. The animal, not the food, is the main factor controlling the quality of the milk.

Quality changes of four different kinds are recognized:

(1) Increase or decrease in quantity, with same yield of solids and fat. The amount of water only changes; the result is a poorer or a richer milk.

(2) No change in quantity, but an increase or decrease in the amount of total solids and fat occurs, thus affecting the proportion of solids and of water. The result is a richer or a poorer milk.

(3) Increase or decrease of a single milk constituent (*e. g.* fat), other solids remaining unaffected, the so-called disproportionate enrichment or impoverishment of the milk. The result is milk richer or poorer in this one ingredient.

(4) Taste may be affected.

It is more particularly the third modification in the quality of milk in which the average feeder appears to believe, but which is found by investigators to be comparatively of rare occurrence.

ABSTRACTS OF RESULTS OF EXPERIMENTS INDICATING THAT CHANGES IN FEEDING MAY ALTER THE QUALITY OF MILK.

The advocates of the doctrine of the non-effect of food upon the quality of milk (per cent. of fat and its relation to that of the other solids) base their views upon a vast amount of experimentation. It is but fair to say, however, that a few feeding tests appear to have resulted in altering the quality of milk to some extent. The barest summarizing of the evidence that quality is not dependent on food would fill a volume. A resume and study of the contrary evidence will take less space, and may prove helpful in connection with the consideration of the results obtained in the present series of trials. The list is probably not exhaustive, but is thought to include the more prominent experiments indicating the possibility of altering the quality of milk by feeding.

1866, Stohmann*; 1 experiment, 2 goats, 3-week feeding periods, 2 weeks preparatory, 1 week experimental.

Rations: Hay, ground flaxseed (basal); hay, extracted flaxseed meal, poppy oil (experimental, enriched with fat); hay, ground flaxseed meal, extracted with ether or with carbon bisulphide to remove oil (experimental, amount of fat greatly lessened); hay, extracted flaxseed meal in large quantities (experimental, enriched with protein); hay, extracted flaxseed meal, flour (experimental, enriched with carbohydrates).

The following table is compiled from data given:

Nature of Ration.	Goat No. I.			Goat No. II.		
	Per cent. of Total Solids.	Fat.	Ratio of fat to solids not fat.	Per cent. of Total Solids.	Fat.	Ratio of fat to solids not fat.
Basal.	12.01	3.54	1:2.39	12.35	3.48	1:2.55
Fat increased.....	11.99	3.71	1:2.23	12.38	3.74	1:2.31
Fat diminished.....	10.90	2.87	1:2.80	11,02	2.48	1:3.44
Protein increased.....	10.09	2.52	1:3.00	12.45	3.03	1:3.11
Carbohydrates incr'sed	12.54	3.44	1:2.65	13.00	3.29	1:2.91

*Journ. f. Landw., II, 4 (1869), pp. 166-172.

The decrease in quality coincident with the elimination of a large part of the fat is striking. The gain in quality following the addition of the poppy oil is likewise notable, a higher fat percentage and a narrow ratio of fat to solids not fat being obtained.* The addition of protein seems to lower the quality of the milk very decidedly, an observation which is at variance with others given in this resume. All these differences are pronounced. How far these results are applicable to bovine feeding is of course questionable.

1868–1877, G. Kuhn†; 12 series, 48 experiments, 30 cows, 21-47 day feeding periods, including preliminary portions.

Rations: Hay, straw and mangolds (basal); same with palm nut meal (experimental).

The following table shows the effect of the palm nut meal ration upon two of the thirty cows.

Approximate Nutritive Ratios.	Gain in per cent. of ingredients following feeding of experimental ration.		Ratios of fat to solids not fat.		Narrowing of ratio resulting from feeding the experimental ration.
	Total Solids.	Fat.	Basal Ration.	Experimental Ration.	
1 : 9.6—1 : 6.6	+0.79	+0 69	1 : 2.61	1 : 2.15	—0 46
do	+0.29	+0.36	1 : 2.47	1 : 2.19	—0.28

While as a rule with ordinary feeding radical changes did not occur, the milk of two cows was affected to a limited extent as regards the fat content when palm nut meal was fed, the gain in quality being entirely fat, a disproportionate increase. Another cow similarly fed was not similarly affected. The amount of digestible protein in the narrower ration was essentially double that of the other ration. Digestible dry matter seems a little scant unless the cows used were of the smaller breeds.

1891-1892. Dean‡; 2 experiments, 6 cows in each; 4 and 5 week periods, 1 week preliminary, 3 and 4 weeks experimental. Rations, 1891, hay, oat straw, silage (basal); hay, linseed meal and corn, cottonseed meal (experimental, narrow); hay, pea, oat and corn meals (experimental, medium). 1892, hay, silage, bran (basal); hay, silage, pea, oat and barley meals (experimental).

	Nutritive Ratios.	Per cent. of			Ratios of fat to solids not fat.	Widening of ratio resulting from feeding the experimental ration.
		Total Solids.	Fat.	Solids not fat.		
Narrow.....	1 : 3.9	12.11	3.49	8.62	1 : 2.47	
Medium.....	1 : 6.8	11.62	3.25	8.37	1 : 2.57	+0.34
Wide.....	1 : 25.6	11.46	3.67	7.79	1 : 2.13	
Basal-wide.....	?	12.30	3 61	8.69	1 : 2.41	
Exp't'l-narrow..	?	12 51	3.48	9.03	1 : 2.60	+0.19

*Compare with this the striking results from adding digestible (emulsified) fat to the ration, obtained by Soxhlet in 1896 (cited on p. 158 this report).

†Journ. f. Landw., 22 (1874), pp. 168-224, 295-352; 23 (1875), pp. 481-522; 24 (1876), pp. 173-195, 381-415; 25 (1877), pp. 332-376. The table in the text was adapted from matter given in 25, pp. 334 and 352.

‡Rpts. Ont. Exp. Farm, 17 (1891), pp. 154-160; 18 (1892), pp. 204-206.

The rations and nutritive ratios in the first experiment were very unlike. Digestible dry matter seems to have been plentiful throughout, but protein was almost entirely lacking in the wide ration. The digestible proteins in in the medium and narrow rations were respectively four and five times greater in amount than that of the wide ration. These differences were less in the second test, yet the rations were widely variant. The results of the first test are very different from those shown by any other investigator. Solids not fat were uniformly reduced, and to a remarkable extent on the wide ration and the fat percentage ran high with every cow. The milk made on the narrow ration was average in quality, while that made on the ration of medium balance was poorest. Again in the second test the milk made on the wide ration was slightly richer in fat and notably poorer in solids not fat though to a less degree than in the former trials. In every other case cited in this list, enrichment of milk and its disproportionate increase in fat have followed liberal feeding; in these instances this result seems to have been brought about by curtailment of the food.

1891, Wilson, Curtiss, Patrick and Kent*; 1 experiment, 4 cows, 31-day feeding periods, 10 preliminary, 21 experimental.

Rations: Clover hay, corn fodder, corn and cob meal (basal); clover hay, corn fodder, "sugar meal" [gluten meal], (experimental).

Approximate Nutritive Ratios.	Gain in per cent. of ingredients following feeding of experimental ration.		Ratio of fat to solids not fat.		Narrowing of ratio resulting from feeding the experimental ration.
	Total Solids.	Fat.	Basal Ration.	Experimental Ration.	
1:13.1—1:5.7	+0.70	+0.57	1:2.54	1:2.21	—0.33

The amount of total nutrients fed seems to have been somewhat scant, and the digestible protein in one ration was probably double that of the other. A very decided disproportionate enrichment of the milk seems to have followed the use of the narrower ration. Jordan† calls attention to a later feeding trial carried out by the same investigators,‡ in which the same grain feeds were again fed in similar quantities, not, however, with this particular point of food effect upon milk quality as a prime object. Soiling crops of various kinds and pasturage were used in place of the clover hay and corn fodder. The plan of the trial was somewhat complicated by other issues, yet the results may be used with a considerable degree of confidence as illustrative of the matter now under discussion. Nutritive ratios cannot be stated even approximately, but were probably about as varied as in the former test.

*Bul. Iowa Exp. Sta., 14 (1891), pp. 123-142.
†Rpt. Me. Bd. Agr., 38 (1895), p. 148.
‡Bul. Iowa Exp. Sta., 15 (1891), pp. 274-283.

Approximate Nutritive Ratios.	Gain in per cent. of ingredients following feeding of experimental ration.		Ratio of fat to solids not fat.		Narrowing of ratio resulting rom feeding of experimental ration.
	Total Solids.	Fat.	Basal Ration.	Experimental Ration.	
?	+0.05	+0.05	1:2.53	1:2.50	—0.03

The comparison of the results of the two trials is suggestive:

1891, Fleischmann,* states that "the fact long believed to be true in practice, that in general it is possible by increasing the amount of food nutrients to make the milk of cows richer in fat, absolutely as well as relatively, would seem to be fully confirmed." This statement is made at the close of a long article descriptive of a year's feeding trial with 16 cows. The determination of the effect of food upon the quality of the milk was at best a mere incident of the tests, which were directed at the solution of very different problems.

Full data of production are given, but no statements whatever are presented regarding the amounts of the various foods eaten, their analyses, digestibilities, etc. The dates of feeding changes and the amounts of fodder and feeds fed (not eaten) comprise all the information at hand upon this side of the subject. It is impossible, save at the expense of a vast amount of work and in a very unsatisfactory way, to confirm or to disprove the statement by the use of the data given. It should be said, however, that Fleischmann is universally recognized as an authority. He would hardly have made the remark unless it were based on evidence which seemed sufficent to him, presented in the work then in hand or derived from former experiments.

1892–95, Cooke†, and, later, the writer‡; 9 experiments, 36 cows, 4-week feeding periods, 10 days preliminary, 18 days experimental.

Rations: Hay, corn meal, wheat bran, silage (basal); (1) same with cream gluten meal; (2) same with Buffalo gluten feed; (3) same with corn germ feed; (4) same with King gluten meal; (5) same with Chicago maize feed; (6) same with corn oil cake; (7) same with Atlas gluten meal (experimental). In each case four pounds daily of the by-product replaced the same weight of equal parts corn and bran except that when Chicago maize feed was used it entirely replaced the corn and bran. The nutritive ratios of the many basal rations were probably close to 1:10. Several other tests of these by-products have been at this station made which are not included in the following list. These were less carefully conducted than those here cited, being of a rather inconsequential nature.

*Landw. Jahrb., 20 (1891), Sup. II, p. 368.

†Rpt. Vt. Exp. Sta., 6 (1892), pp. 143-153; Bul. 33 (1892).

‡Bul. Vt. Exp. Sta., 48 (1895), pp. 70-78; Rpt. 9 (1895), pp. 220-223.

Experimental grain food.	Number of cows.	Approximate nutritive ratios of the experimental rations.	Gain or loss in per cent. of total solids following feeding of experimental ration.	Gain in per cent. of fat following feeding of experimental ration.	Ratio of fat to solids not fat on corn and bran ration.	Ratio of fat to solids not fat on experimental grain ration.	Narrowing of ratio of fat to solids not fat, following feeding of experimental rations.
1 Cream Gluten Meal..	3	1:5.9	+0.26	+0.37	1:2.06	1:1.88	—0.18
2 Buffalo Gluten Feed.	3	1:7.9	—0.07	+0.05	1:2.09	1:2.04	- 0.05
3 Corn Germ Feed....	3	1:10.5	+0.07	+0.13	1:2.05	1:1.98	—0.07
4 King Gluten Meal...	7	1:5.9	+0.01	+0.15	1:1.96	1:1.88	—0.08
5 Chicago Maize Feed.	7	1:6.5	—0.02	+0.04	1:1.91	1:1.88	—0.03
6 Corn Oil Cake.....	6	1:8.1	—0.03	+0.04	1:1.81	1:1.78	—0.03
7 Atlas Gluten Meal...	6	1:7.2	+0.13	+0.20	1:1.93	1:1.83	—0.10

The digestible dry matter eaten was in every case up to the demands of the Wolff standard. Digestible protein was deficient in the corn and bran and corn germ feed rations, and slightly lacking in some of the others.

In every case the by-product tended to enrich the milk disproportionately. The differences in no case are as pronounced as are noted in the other tests cited in this article, and in three cases are infinitesimal. Cream gluten meal and Atlas gluten meal furnished results which are fairly positive. The result following the use of the wide corn germ feed ration is interesting, and rather out of the usual course.

1893, Jordan*; 1 experiment, 3 cows, 5-week periods, 1 week preliminary, 4 weeks experimental.

Rations: Hay and corn meal (basal); hay, cottonseed, gluten and corn meals (experimental).

Approximate Nutritive Ratios.	Gain in per cent. of ingredients following feeding of experimental ration.		Ratio of fat to solids not fat.		Narrowing of ratio resulting from feeding of experimental ration.
	Total Solids.	Fat.	Basal Ration.	Experimental Ration.	
1:12.3—1:6.7	+0.59	+0.42	1:2,13	1:1.97	—0.17

Ample amounts of digestible dry matter were eaten in each case. The amount of protein eaten from the narrow ration was more than double that from the wide ration. The feeding periods were comparatively long. The method of sampling the milk does not entirely approve itself to the writer.†

1894, Lindsey‡; 1 experiment, 6 cows, 21-day periods, 7 days preliminary, 14 days experimental.

*Rpt. Me. Exp. Sta., [no. vol.] (1893), pp. 73-82.

†It should be stated that three cows were used in this experiment; that the milk of two was clearly better while the nitrogenous ration was being fed; and that the milk of the third cow continued to improve throughout the experiment, independently of the ration. Our present purpose, however, concerns simply the positive evidence of quality variations occurring coincident with feeding changes.

‡Rpt. Mass. (State) Exp. Sta., 12 (1894), pp. 42-77.

Rations: Silage, stover, corn meal, wheat bran (basal); same with cottonseed meal (experimental, medium); same with cottonseed meal and Buffalo gluten feed (experimental, narrow).

Approximate Nutritive Ratios.	Gain in per cent. of ingredients following feeding of experimental ration.		Ratio of fat to solids not fat.		Narrowing of ratio resulting from feeding of experimental ration.
	Total Solids.	Fat.	Normal Ration.	Experimental Ration.	
1:10—1:4.8	+0.23	+0.41	1:2.25	1:2.00	—0.25
1:5.8—1:4.8	+0.17	+0.30	1:2.02	1:1.87	—0.15

Digestible dry matter was plentiful in every case; digestible protein was lacking only in the wide ration. The decided quality change coincident with the comparitively slight alteration in nutritive ratio in the second case is rather out of the common. The brevity of the feeding periods may be justly criticised, a fault which is recognized by the investigator.

1896, Soxhlet*; no data; extent and nature of experiments not stated, conclusions and theoretical discussion alone being given.

It may be fairly assumed that so eminent an authority would hardly make positive statements unless they are based upon careful investigation. This premise being granted, Soxhlet's contribution to the study of the effect of food upon the quality of milk may justly be termed the most important evidence yet adduced upon the affirmative side of the controversy. The main points made are as follows: That lowered quality (0.70 per cent. decrease in fat) followed the feeding of large quantities of readily digestible carbohydrates; that bettered quality did not accompany increase of protein, the fat content remaining essentially unchanged when 4 pounds of rice gluten (71 per cent. protein) was added to a hay ration†; that the fat of the food alone is capable of producing a disproportionate or one-sided increase in the fat content of the milk; that the fat of the food causes a transmission of the body fat, produced largely from the carbohydrates, to the milk without itself passing into it; that provided extraneous fat be in a form which admits of digestion, its addition to a ration materially increases the fat content of milk, as was shown when emulsified sesame oil, linseed oil or tallow, thoroughly mixed with drinking water, were used‡; that similar tests with unemulsified fats, reported by Fleischer, G. Kuhn and Stohmann,§ which resulted in no quality change, and which have hitherto been held to be strong arguments

*Wochenbl. landw. Ver. Bayern, 40 (1896); reviewed in Exp. Sta., Rcd. 8 (1896-97), pp. 939, 1016-1019.

†This result is strikingly different from those obtained by Kuhn, Wilson et. al., Cooke, Jordan and Lindsey, already cited.

‡Apparently these abnormal rations were fed but a short time (4-8 days). The enormous increases in fat which were observed might not have continued indefinitely. Moreover, the effect upon the health of the cow of this class of feeding is not clear.

§Similar results have likewise been obtained in this country. See Bul. N. H. Exp. Sta., 20 (1892); Bul. Cornell Exp. Sta., 92 (1895).

against the theory of food affecting quality, are invalid, because the fats did not digest. Soxhlet calls attention in this connection to the previously overlooked experiment on goats made by Stohmann.*

A decided enrichment of milk following a change of food is shown in this report under the heading II. 2, "Corn Silage vs. A Silage from Cow Peas and Soja Beans". It is thought, however, that a shrinkage in the milk flow which occurred coincident with the increase in quality is at fault in the matter rather than change of food.

While several of these experiments have given results apparently very positive in their nature, it should be noted that widely different nutritive ratios were frequently used, a condition which is excepted in the statement on page 151.

The reader should not lose sight of the vast amount of negative evidence hitherto referred to while considering the affirmative side of the discussion.

The "period length" experiment furnishes suggestive data upon this matter of the effect of food upon the quality of milk. The following table shows the increase or decrease in the per cent. of total solids and fat, and the change in the ratios of fat to solids not fat when Atlas gluten meal was substituted for corn meal and wheat bran in the ration of the cows fed therewith for various lengths of time. The upper half of the table is made, using averages by addition; the lower half, using averages by cross division. (See foot note to Table V in the appendix).

QUALITY OF MILK AS AFFECTED BY CHANGE IN FOOD.

Period length in weeks.	Total Solids.	Fat.	Per cent. of total; total=100.		Ratio of fat to solids not fat.		Differences in ratios resulting from feeding of experimental ration.
			Total Solids.	Fat	Corn and Bran.	Atlas Gluten Meal.	
4	—0.06	+0.10	0	+2	1:2.03	1:1.95	—0.08
6	—0.20	—0.04	—1	—1	1:2.01	1:1.99	—0.02
7	—0.42	—0.13	—3	—2	1:1.81	1:1.80	—0.01
8	—0.23	—0.10	—1	—2	1:1.71	1:1.72	+01.0
*4	+0.13	+0.20	+1	+4	1:1.93	1:1.83	—0.10
4	—0.10	+0.10	—1	+2	1:2.06	1:1.97	—0.09
6	—0.13	0.00	—1	0	1:2.05	1:2.02	—0.03
7	—0.23	—0.02	—2	0	1:1.88	1:1.84	—0.04
8	—0.42	—0.24	—3	—6	1:1.76	1:1.81	+0.05

*Rpt. Vt. Exp. Sta., 9 (1895), p. 222.

These tables are very suggestive. When the Atlas ration of medium balance replaced the wide corn and bran ration *for a short time* (four weeks or less), a somewhat richer milk was made, one in which the fat was increased, and the solids not fat remained essentially unaffected. This effect was not observed, however, *when the ration was fed six weeks or more*, the quality remaining unaltered, or if anything growing a shade poorer.

*Cited on page 152 of this report.

Nine cows fed in periods four weeks long testify that the quality of milk is slightly bettered, and the ratio of fat to solids not fat narrowed by the substitution of Atlas gluten meal for corn and bran in the ration. Eight other cows fed in periods from six to eight weeks long testify to the contrary.

As an aid towards reconciling this apparent conflict of evidence, appeal may be made to the preliminary portions of the feeding periods. It is unsafe as a rule to lay stress upon the production immediately following marked changes in feeding. In the present case and for the present purpose, however, the data is of much value. It should be remembered, moreover, that the preliminary portions of the feeding periods used with the four sets of cows were 10, 15, 18 and 20 days long, and that, as feeding periods go, they were moderately respectable in length; also that every barn and laboratory detail was as scrupulously observed during the preliminary as during the experimental portions.

The following tables are similar in character to those immediately preceding and throw considerable light on the disputed point.

QUALITY OF MILK GIVEN FOR FROM 10 TO 20 DAYS AFTER A CHANGE IN FOOD, *i. e.*, IN THE PRELIMINARY PERIODS.

Period length in weeks.	Number of days' feeding.	Total Solids.	Fat.	Per cent. of total; total=100.		Ratio of fat to solids not fat.		Differences in ratios resulting from feeding of experimental ration.
				Total Solids.	Fat.	Corn and Bran.	Atlas Gluten Meal.	
4	10	—0.01	+0.18	0	+4	1:2.05	1:1.93	—0.12
6	15	+0.12	+0.28	+1	+6	1:2.06	1:1.91	—0.15
7	18	—0.04	+0.11	0	+2	1:1.81	1:1.75	—0.06
8	20	—0.25	+0.08	—2	+2	1:1.73	1:1.65	—0.08
4	10	—0.03	+0.18	0	+4	1:2.07	1:1.86	—0.21
6	15	+0.02	+0.22	0	+5	1:2.10	1:1.96	—0.14
7	18	—0.14	+0.06	—1	+1	1:1.85	1:1.79	—0.06
8	20	—0.21	+0.09	—1	+2	1:1.79	1:1.71	—0.08

Nearly every figure in these tables is larger than the corresponding figure in the preceding tables, every increase in quality greater in the first two or three weeks following the change in feeding than it was when the animal had become thoroughly used to the new regime. The extent of the quality change is notably less as the lengths of the preliminary feeding periods increase, an observation which is in line with the general trend of the results.

Further than this it is worthy of note that the cows tended to better their milk slightly as the length of time while feeding on corn meal and wheat bran extended, but to lower its quality somewhat as the feeding on the Atlas ration was continued. This point is well brought out in the following table:

QUALITY OF MILK AS AFFECTED BY PROLONGING THE FEEDING ON ONE RATION.

	CORN AND BRAN.							
Period Length.....	Five weeks.		Six weeks.		Seven weeks.		Eight weeks.	
Portion of Period.	Total Solids.	Fat.	Total Solids.	Fat.	Total Solids.	Fat.	Total Solids.	Fat.
Preliminary.....	13.77	4.52	14.03	4.58	14.95	5.32	15.16	5.55
Experimental.....	13.83	4.56	14.14	4.70	15.15	5.47	15.17	5.59
Gain in quality following prolonged feeding on corn and bran.....	+0.06	+0.04	+0.11	+0.12	+0.20	+0.15	+0.01	+0.04
	ATLAS GLUTEN MEAL.							
Preliminary.....	13.76	4.50	14.15	4.86	14.91	5.44	14.91	5.63
Experimental.....	13.77	4.66	13.94	4.66	14.85	5.39	14.94	5.49
Loss in quality following prolonged feeding on Atlas gluten meal.....	+0.01	−0.04	−0.21	−0.20	−0.06	−0.04	+0.03	−0.14

It was as if the animal passing from the Atlas to the corn and bran ration was depressed in spirits at the poorer food, but later pulled herself together and did better; and that in returning again to the Atlas ration she was temporarily exhilarated, but in time resumed her normal condition. No relation between the extent of these changes and the various period lengths was traced.

The upshot of these series of comparisons appears to be that *the 4-week period did not give results which are entirely trustworthy touching the quality of the milk given on the Atlas ration. The 6-week period, however, and those yet longer in duration, gave satisfactory results.*

Combining the conclusions on both quantity and quality, it would appear that *a 4-week feeding period accurately indicated in the present case the character of and probably the extent of quantity changes, but that the slight improvement observed in quality was temporary, and not to be relied upon as likely to continue under the conditions of prolonged feeding on a single ration.* Since this latter effect is but slight and entirely without practical significance, and since the results of longer feeding discount it, one need not lose faith in the essential accuracy of past observations in which 4-week periods have been used.

On looking up the period lengths in the experiments which have been cited in favor of the proposition that the richness of milk could be affected by changes in feeding; they were found to be as follows:

Stohmann, 3 weeks (2-1)*; G. Kuhn, 21-47 days; Dean, 4 and 5 weeks (1-3, 1-4); Wilson *et. al.*, 31 days (10-21); Cooke, 4 weeks (10 days, 18 days); Hills, 4 weeks (10 days, 18 days); Jordan, 5 weeks (1-4); Lindsey, 2 weeks (1-1);

*Figures in parenthesis refer to the division of the periods into preliminary and experimental portions. Thus in Stohmann's work the 3-week periods were divided into 2 week preliminary and 1-week experimental portions.

Fleischmann and Soxhlet, not given in the original. In but three cases did the feeding periods last longer than four weeks. The outcome of the present series of trials raises a serious question as to the validity of the results obtained in experiments in which feeding periods of four weeks or less duration were used. If the results of our experiments are confirmed by future work, the amount of trustworthy evidence in favor of the possibility of "feeding fat into milk" by normal means will be but small.

Should the failure of the 4-week period to justify itself in this one particular of quality change condemn it for future use? Are 6-week periods safer? This question cannot be dogmatically answered. Circumstances must determine. The investigator is between Scylla and Charybdis, questionable results because of too brief feeding periods on the one hand, and the effects of exaggerated individuality upon the other. The shorter period length possesses several distinct advantages over the longer ones, the most important being the increase in the number of observations which can be made in the same time with the same animals, food, care, analytical work, etc. Thus in the present case sets 4 and 8 were fed precisely the same length of time, and contained the same number of cows. Twelve comparisons, twelve measures of the relative efficiency of the two rations were possible with set 4, and but three with set 8. Three periods are needed to furnish a single comparison, and if these occupy 24 weeks or more, changes in season, temperature, habit of life of animal, etc., are likely to introduce disturbing factors.

The exaggeration of the effects of individuality caused by the curtailment in the number of comparisons may frequently introduce as great inaccuracy as does the brevity of the feeding periods. Thus in the present case the pluses and minuses of the first and second quantity tables (page 149) for the two 4-week and one 6-week period-comparisons each bear a fairly close resemblance to the other. For instance, the battery of pluses in this year's 4-weeks' test (+11+11+15+12+12+15) is very similar to the aggregation of minuses (–13–12–14–15–14–16). The same three cows and six comparisons figure on both sides when the increase or the decrease in product from one or the other ration is measured. The dissimilarity of the figures of the 7-weeks' test is equally plain (+3+3+5+6+6+6) (–20–16–15–20–16–16). But one cow and one comparison is found on each side, and the cows are not the same. The effects of individuality upon the outcome of the tests are neutralized in the one case, and magnified in the other. The character of the change in product is the same in both cases when 7-week periods were used, but its extent was quite different with the two cows.

This series of trials has not settled the question. It was not expected that it would. It is hoped that the tests of the coming winter will shed more light upon the matter. The results now at hand tend on the whole, however, to confirm the writer's faith in the 4-week period as a reliable measure of practical results to be expected from changes in feeding. With an ample number of cows, and with twenty-five or more weeks ahead before the pasture season begins, 5 or 6-week periods might prove better.

5. THE RELATIVE FEEDING VALUES OF TWO RATIONS OF EQUAL BALANCE.

The relative feeding values of two rations are usually measured by feeding them in alternating periods of greater or less lengths to one or more animals, the necessary weights, samples, analyses, etc., being taken and made. As a rule the rations thus compared have varied more or less in their contents of digestible nutrients and in their nutritive ratios, and not infrequently have proved to be decidedly different in their effect upon production. These differences, however, have not been found to be of necessity proportional to the variance in the rations tested. It is unsafe to assert, moreover, even when the same amounts of each of the nutrients are fed in each ration in different feeding stuffs, that production will be uniform. The chemist's analyses and the investigator's digestion experiments may show identical amounts of digestible food in each case, but the final arbiter, the cow, may do better on one ration than on the other, or she may not. The presumption, however, is always in favor of lessened variations as food supplies become equalized.

A test of this point, *i. e.* the variation in production to be expected when, in two different rations, essentially the same amounts of the various digestible nutrients are eaten and when nutritive ratios remain closely alike was planned for the past winter. Atlas gluten meal, which had been found effective as compared with corn and bran, was made the basis of the grain ration in one case and cottonseed and linseed meal in the other case, the two rations being made up as follows: I, hay 10 lbs., silage ad libitum, mixed feed No. 1 (3 lbs. wheat bran, 2 lbs. corn meal, 1½ pounds each of cottonseed and linseed meals) 8 lbs.; II, hay 10 lbs., silage ad libitum, mixed feed No. 2 (3 lbs. wheat bran, 2 lbs. corn meal, 4 lbs. Atlas gluten meal) 9 lbs. Both rations were eaten well and the cows appeared to thrive on them. All the cows were on the same ration at the same time throughout the test, a condition which is not ideal but which an emergency rendered imperative. It was intended that the rations should contain as nearly as might be the same amounts of the different digestible nutrients. This condition was difficult to meet in the present case. If enough Atlas meal was used to give the same protein as in the cottonseed-linseed ration all the nutrients of a carbohydrate nature in the Atlas ration, and especially the fat, ran high. If the amounts of digestible fat, which some investigators consider a controlling factor in determining quality, were made even, the protein in the Atlas ration sank too low. It was finally decided to feed as nearly as might be the same amounts of digestible protein in each ration. This aim was in a slight measure defeated by the lower quality of this year's Atlas meal, as compared with that fed last year.* The averages were as follows:

*Owing to pressure of other work the meal samples were stored and not analyzed until after the feeding tests were finished.

AVERAGE POUNDS OF DIGESTIBLE PROTEIN EATEN IN 18 DAYS.

Ration.	Red Top	Brownie	Max Belle	Bettie	Clover	Jeannie	Eulalie	Kinkora	Julia
Cottonseed-linseed,	42.9	41.6	38.3	39.6	41.8	40.5	43.3	38.6	40.1
Atlas,	41.8	38.6	36.2	37.3	40.1	38.0	41.1	36.3	37.2
Differences	1.1	3.0	2.1	2.3	1.7	2.5	2.2	2.3	2.9
Per cent. difference	3	7	5	6	4	6	5	6	7

The differences in protein average 5 per cent. While protein ran fairly uniform it was impossible to keep nutritive ratios the same, owing to the greater amounts of digestible fibre, fat and nitrogen-free extract in the Atlas meal and the large amount thereof which was fed.* In a repetition of such a test we should probably add starch and some emulsified fat in small quantities to the cottonseed-linseed ration to render the relative amounts of these nutrients more closely comparable.

Because of the reasons given above the nutritive ratios averaged 1 : 6.3 (cottonseed-linseed) and 1 : 7.3 (Atlas). The rations therefore were not strictly of "equal balance" in the ordinary acceptance of the term, but did contain essentially equal amounts of protein. Inasmuch as this term "equal balance" is fairly descriptive of the nature of the test, it is retained even though not quite correct.

The nine cows chosen for this test were not in as good condition as were the fifteen selected for the period length tests. Five were fed for but three periods only, since they were, at the close of this time, beginning to go dry.

The following summary of percentage differences is taken from the "difference tables" of the appendix. The table shows the increase or decrease (expressed as percentage, total=100) in dry matter eaten, in milk, total solids and fat given, and of products per 100 pounds of dry matter eaten, both in the total and in the experimental portions of the rations, when an Atlas (nutritive ratio 1 : 7.3) replaced a cottonseed-linseed ration (nutritive ration ratio 1 : 6.3), or *vice versa*.

SUMMARY OF DIFFERENCE TABLES VI. (*b*) (APPENDIX.)

RATION.	Dry Matter.	Dry Matter in Experimental Fodder.	Quantity of Milk.	Total Solids, Per Cent.	Fat, Per Cent.	Quantity of Total Solids.	Quantity of Fat.	Products per 100 lbs. of Dry Matter. Entire Ration. Milk.	Solids.	Fat.	Experimental Fodder. Milk.	Solids.	Fat.
Atlas ± cottonseed-linseed,	+4	+11	+1	−1	−2	+1	0	−5	−6	−6	−12	−13	−14
Cottonseed-linseed ± Atlas,	−3	−13	−3	+2	+4	0	+1	+1	+3	+4	+ 9	+11	+12
331 days feeding on Atlas ± 331 days feeding on cottonseed-linseed	+3	+12	+1	−1	−3	0	0	−4	−7	−6	−12	−13	−14

*It should be stated that the digestion coefficient given for crude fibre in Atlas gluten meal by Lindsey (100) was used in calculating the ratios. Private correspondence with him indicates that this figure is probably much too high. He suggests 50-70 as more likely to approximate the truth. Had the lower figure been used the nutritive ratios on the Atlas ration would have been reduced a tenth or so.

These results may be summarized as follows:

1. Atlas compared with cottonseed-linseed. Four per cent. more total dry matter eaten in the form of the Atlas ration than was eaten in the cottonseed-linseed ration produced 1 per cent. more milk and total solids and no more fat.

2. Cottonseed-linseed compared with Atlas. Three per cent. less total dry matter eaten in the form of the cottonseed-linseed ration than was eaten in the Atlas ration produced 3 per cent. less milk, the same amount of total solids and 1 per cent. more fat.

3. Atlas compared with cottonseed-linseed (331 days' feeding). Four per cent. more dry matter eaten in the form of the Atlas ration than was eaten in the form of the cottonseed-linseed ration produced 1 per cent. more milk but no more solids or fat.

4. The milk made on the cottonseed-linseed ration was somewhat the richer of the two but the enrichment could hardly be termed one-sided, the ratio of fat to solids not fat narrowing very slightly (Atlas 1 : 1.71, cottonseed-linseed 1 : 1.68).

5. One hundred pounds of dry matter both in the entire ration and in the grain portion thereof (experimental portion) proved more efficient in the cottonseed-linseed than in the Atlas ration, making on the average about 6 per cent. more product. This increase is not sufficient to warrant great stress being laid upon it, yet, because of the large number of cows used and the almost perfect uniformity of the trend in each individual case, it is thought that the difference lies outside the pale of possible experimental error and that it is mainly a food effect.

6. The dry matter of the rations being of nearly equal digestibility (cottonseed-linseed 75, Atlas 76) the conclusion in the last paragraph may properly be applied likewise to digestible dry matter.

7. It has already been pointed out that the excess of protein in the cottonseed-linseed ration was but 5 per cent. In these cases of essentially equal consumption of protein one ration proved somewhat more effective than another. The ration containing the most digestible carbohydrates, the most digestible fat and the most digestible dry matter gave the smallest returns.

Production was in favor of the narrower ration. It cannot be predicted what the effect would have been had it been possible to feed equal quantities of protein and also of carbohydrates. It is expected to repeat this test during the coming winter with such modifications as will insure as nearly as may be similarity in amounts of digestible nutrients eaten and of nutritive ratios.

6. EXPERIMENTAL ERROR IN FEEDING TESTS.

Data upon this point have hitherto been accumulated at this station and published in previous reports.* The results were quite uniform in both cases and there did not appear to be much need of repeating the work. It so happened, however, that several of the station cows entered upon the barn life in the fall of 1896 so far along in lactation that they could not be used safely in the longer feeding experiments. These were fed uniformly until they went dry. In five cases this feeding continued for twelve or more weeks during which time sufficient milk was given to permit fairly reliable deductions. Three heifers with their first calf were likewise fed uniformly for twenty-four weeks, it being deemed inadvisable to use such in regular feeding trials. One fresh mature cow was fed uniformly for sixteen weeks. Hay, silage, corn-fodder, beets, a few carrots and mixed feed No. 1 were used.

Since fodder and milk weights and analyses are at hand, and since the animals were in every respect treated as were those under regular feeding experiments, the data may be used to add to our present information upon this subject. It should be said, however, that the cows whose records are thus used were not as well suited for the purpose as fresher animals would have been. These, however, were being used in other experiments which were considered to be relatively more important. The cows were in decidedly poorer condition for experimental purposes than were those used in the similar test described in the last report.

The relative merits of two rations in a feeding test are measured by the variations in production which take place coincident with food changes. It has been claimed by some investigators that as great fluctuations in product may occur upon uniform rations as have in some cases served as the basis for deductions regarding the effect of food.† The experience at this station in former tests has been quite different from this, uniformity of ration being accompanied by essentially unchanged production. Of course one can seldom if ever assert absolutely that food variation alone is concerned in a given change in production. Yet in proportion as the number of the animals in the test increases, and as various environmental conditions are controlled, and as results are more pronounced and uniform, greater certainty attaches to the deductions.

In the present trials the amount of food eaten in the various periods by the same cow was quite uniform. Towards spring, however, corn fodder was eaten with reluctance and the nutritive ratio of the heifers' rations became narrowed. Enough digestible dry matter was eaten in practically every case and the rations approximated the Wolff standard, varying, when eaten well, from 1 : 5.2 to 1 : 6 and averaging 1 : 5.7.

*Rpts. Vt. Exp. Sta., 3 (1889), pp. 62-64; 9 (1895), pp. 225-228.

†According to Exp. Sta. Rcd., 7 (1896-97), p. 979-980, Sebalien, (Molk. Zeit., 9 (1895), 44. pp. 677-678) cites Fleishmann's experiments (Landw. Jahrb. 20 (1891), Sup. II., pp. 1-368) as showing wide variations in milk production upon uniform feeding.

The following table shows the increase or decrease (expressed as percentages, total=100) in dry matter eaten, in milk, total solids and fat given, and of products per 100 pounds of dry matter, both in the total and in the experimental* portions of the ration, upon a uniform ration, in 4-week periods.

SUMMARY OF DIFFERENCE TABLES VI (*c*) (APPENDIX.)

Total Dry Matter Eaten.	Dry Matter Eaten in Silage or Corn Fodder.*	Quantity of Milk.	Total Solids, per cent.	Fat, per cent.	Quantity of Total Solids.	Quantity of Fat	Products per 100 Pounds of Dry Matter.					
							In Entire Ration.			In Experimental Fodder.*		
							Milk.	Total Solids.	Fat.	Milk.	Total Solids.	Fat.
0	+2	+2			+2	+3	0	+1	+2	−2	−2	−1
0	+2	0			0	+1	0	+1	0	−1	0	0
0	0	−1	0	−1	−1	−1	0	0	−1	+1	+1	+1

Each of the first two horizontal lines of figures represents the average of twelve comparisons ; the percentage differences of two 360-day periods furnish the third horizontal line. See appendix for full data.

Practically no change occurred in quantity or quality of product when nine cows were fed a uniform ration for from twelve to twenty weeks. A pound of dry matter produced as much milk, total solids and fat at one time as at another, lactation stages being equalized.

Of 29 comparisons other than of food, 10 are zeros, 13 are one, 5, two and 1, three per cent, an average variation of one per cent.

In last year's tests two-thirds of the individual comparisons were 4 per cent. or less apart, and it was clear therefore that the favorable outcome was not the result of the happy balancing of many large plus and minus errors. The showing is not so good this year. The limit must be raised to 5 per cent. before two-thirds of the individual comparisons are included. This is due mainly to two causes; first, the cows used were, with but a single exception, far along in lactation, several being almost ready to dry off, and, naturally, shrinking rapidly in milk, yet eating about the same amount of dry matter; second, the cows in the test of 1895-96 ate silage, while all but three in the present trial ate corn fodder, which became somewhat unpalatable toward the late winter and early spring, resulting in lessened amounts of food eaten and a decided change in the nutritive ratios and the rations.

In this year's tests there were 23 zeros, 24 ones, 31 twos, 24 threes, 17 fours and 17 fives to be found in 209 comparisons of "percentage differences" derived from the records of the individual cows. That is to say, in 23 out of the 209 individual comparisons of products, the difference on one period

*For the purposes of comparison, silage and corn fodder are considered "experimental fodders."

balanced that of the average of the two periods on each side within a limit of less than 1 per cent. of the total. Two-thirds of the entire number of comparisons were 5 per cent. or less apart.

Although not quite as favorable an outcome has resulted in this test as was obtained last year, it is thought that the trials here reported do not cast doubt upon the correctness of the conclusions drawn at that time, and that the same may be safely reasserted as follows :

"Apparently if the animals for feeding tests are carefully selected, and a sufficient number are used, the 'experimental error' may be nearly disregarded. If but two or three animals are used, it will hardly be safe to assert dogmatically that fluctuations of the product are of necessity due to changes in the character of the feeding, unless they exceed four or five per cent. of the larger product."

7. PRACTICAL CONCLUSIONS OF ECONOMIC VALUE.

Attention has already been called (page 141) to the fact that the cows in the "period length" tests gained decidedly in live weight while upon the Atlas ration, and that the cows in the other trials made more or less gain during the winter on other rations. Corn and bran were inferior in this respect to both the Atlas and the cottonseed-linseed ration.

The opinion expressed in the last report* that Atlas gluten meal was superior to equal parts of corn meal and wheat bran as a dairy feed, and that at $16 per ton it was the cheapest protein on the market, has been confirmed and strengthened by the results of the much more extensive tests of the present year. Compared with a ration containing essentially equal amounts of digestible protein, mainly in the form of cottonseed and linseed meals, it proved very slightly inferior.

While these comparisons are interesting and instructive, the study of the financial side of the question is from the practical standpoint of greater importance. This properly involves the cost of the fodders and feeds, the cost of making a pound of milk and a pound of butter, and the fertilizing value of the rations.

FINANCIAL ASPECT.

The relative values, from the financial standpoint, of the rations used in the "period length" and "equal balance" trials are shown in the following tables which give the weights of the various fodders and feeds eaten, and of milk and butter made during the experimental portions of the periods, together with the money values of the foods, and the cost of food per 100 pounds of milk and per pound of butter. The comparisons are not strictly just, since the amount of food eaten does not alter so materially as does the milk flow as the distance from calving increases. Lactation stages can be equalized by calculation so as to put production in different periods upon an even basis. This cannot be done, however, with the food consumption. An excellent illustra-

*Rpt. Vt. Exp. Sta., 9 (1895), p. 223.

tion of this point is seen in the vastly different cost of milk and of butter on the Atlas rations used in the "period length" and in the "equal balance" tests. The cows in the former trials were fairly fresh in milk, while those used in the latter were mainly strippers.

FINANCIAL COMPARISONS OF CORN AND BRAN, ATLAS AND COTTONSEED-LINSEED RATIONS.

Ration.	Pounds of								Money value of food.†	Cost of food in cents for	
	Hay.	Corn meal.	Wheat bran.	Atlas gluten meal.	Cottonseed-linseed meals (equal parts.)	Silage.	Milk.	Butter.*		100 lbs. milk.	1 lb. butter.
Atlas	5539	612	613	3309	——	19812	12047	665	$93.77	77.8	14.1
Corn and bran	5231	2166	2166	——	——	18781	10152	557	85.96	84.7	14.9
Differences in favor of Atlas ration							+1875	+88	+7.81	—6.9	—0.8
Percentage differences							+15	+13	+8	—8	—6
Atlas	3693	810	1215	1620	——	13606	5221	332	$66.74	127.8	20.1
Cottonseed-linseed	4283	869	1303	——	1304	15589	5879	377	75.53	128.5	20.0
Differences in favor of cottonseed-linseed ration							+658	+45	+8.79	+0.8	—0.1
Percentage differences							+11	+12	+12	+1	0

*One and one-sixth times the fat.

†Hay $10.50, bran $13, corn meal $15, Atlas gluten meal $16, silage $3; average market prices for grain feeds, and average estimates of many prominent and successful farmers in the various parts of the state of the values of hay and silage at the barn ready for feeding.

The Atlas ration was more economical than was the corn and bran ration. More milk was made thereon, and the food cost more; hence the milk was made but 8 per cent. and the butter but 6 per cent. cheaper on the richer ration. Atlas gluten meal at $16 is not much cheaper than corn and bran at $15 and $13 respectively.

Apparently the cottonseed-linseed ration made more milk and butter than did the Atlas ration, and cost more. The periods, however, were of different lengths, and the animals were fed some three and some five periods; hence the figures are in reality useful only as means to arrive at the cost of food per unit of production. In this respect absolute equality is found. So far as can be judged under the somewhat irregular conditions of this test, the two rations were financially of equal value.

FERTILIZING VALUE.

The fertilizing value of the various rations should not be overlooked. Using the analyses given upon page 144 and the trade values of 1896-97 for nitrogen, phosphoric acid, and potash in commercial fertilizers (15, 5, and 4½ cents per pound respectively), they are found to be as follows:

FERTILIZING VALUE OF RATIONS.

Ration.	Hay.	Corn and bran.	Atlas gluten meal.	Mixed feeds Nos. 1 and 2.	Silage.	Total.
Atlas ("period length")	$13.92	$ 5.50	$29.32	—	$13.00	$61.74
Corn and bran ("period length")	13.15	19.45	—	—	12.32	44.92
Atlas ("equal balance")	9.28	—	—	$22.27	8.94	40.49
Cottonseed-linseed ("equal balance")	10.76	—	—	23.42	10.23	44.41

These rations were fed uneven lengths of time, and in order to reduce them to a common basis, the total fertilizing value of a month's (30 days) ration for the average cow is calculated and found to be as follows:

Atlas $3.16, corn and bran $2.45, Atlas $3.00, cottonseed-linseed $2.85. Expressing the lowest (corn and bran) as 100, the fertilizing values of the various rations are relatively: Atlas rations, 129 and 122, cottonseed-linseed ration, 116. The differences lie entirely in the grain feeds and mainly in the nitrogen, the corn and bran ration being quite as rich as the others in phosphoric acid and potash. The amount of these ingredients which reach the soil and the crop depends largely if not entirely upon the care with which the manure is handled.

II. FEEDING TRIALS WITH SILAGES AND POTATOES.

During March, April and early May, 1896, feeding experiments were carried out designed to test the relative food values of the following materials:

Corn silage and a silage made from soja bean and cowpea vines.

Corn silage and potatoes.

The tests were secondary to the main experiments of the winter reported on pages 203-236 of the ninth report. Had they occupied a more prominent place in the experimental scheme of the year a few conditions might have been more favorable, particularly in matters of even progress of lactation period. Moreover owing to misunderstanding regarding certain instructions the cows were not weighed, nor were barn temperatures taken. An error occurred also in the date of changing rations in the silage-potato test. While these failures are to be regretted, it is not thought that the general results of the trials are materially affected thereby. These results may be concisely summarized under their respective reference numbers and heads as follows:

1. SUMMARY.

2. *Corn silage vs. mixed silage.* Less but better milk and essentially equal yields of solids and fat were made from somewhat more total dry matter on the soja bean-cowpea silage than when corn silage was fed. A hundred pounds of dry matter in corn silage proved superior to the same amount in the mixed silage.

The mixed silage analyzed but little better than did the corn silage, cost more to grow and harvest, yielded less, and was distasteful to some cows.

The marked increase in the quality of the milk following the feeding of the mixed silage, while suggestive, is not thought to be due as much to change of feed as to a coincident shrinkage in the milk flow.

3. *Silage vs. potatoes.* The potato ration was eaten more freely than was the silage, yet produced neither more nor better milk. A hundred pounds of dry matter and of digestible dry matter in corn silage proved superior to similar amounts in potatoes.

DETAILS OF FEEDING AND COWS USED.

The general conduct of the milking, sampling, feeding, etc., was much the same as was observed in the main experiments of the winter.* Three 4-week feeding periods were used, the experimental ration being fed in the second period. Two cows were used in the test of silages and six in the silage-potato trials.

NAME.	Age.	Calved. 1895	NAME.	Age.	Calved. 1895
Nett	7	Sept. 24	Regina	7	Dec. 26
Jersey Lily	4	Oct. 18	Flox	6	Jan. 1, '96
Bess	10	Mch. 6, '96	Jessie	6	Nov. 28
Golden Rod	5	Jan. 7, '96	Marjory	7	Jan. 15

FODDERS AND FEEDS USED.

The fodders and feeds used, except the hay, were frequently sampled and analyzed. Four samples of each "roughage" were taken at each sampling, and the per cent. of dry matter determined, following which they were combined to make one analytical sample. Over forty analytical samples contribute to the averages given upon the following page.

*Rpt. Vt. Exp. Sta., 9 (1895), pp. 204-206.

AVERAGE ANALYSES OF FODDERS AND FEEDS USED.

Fodders and Feeds.	Original Substance.		Composition of Dry Matter.							
	Water.	Dry matter.	Crude ash.	Crude protein.	Crude fibre.	Nitrogen-free extract.	Ether extract.	Nitrogen.	Phosphoric acid.	Potash.
Corn silage (early in test)...	73.34	26.66	6.19	9.53	24.78	56.54	2.96	1.52	0.46	1.50
" " (late in test)....	73.13	26.87	7.41	10.13	27.58	52.12	2.76	1.62	0.53	1.65
Mixed silage.....	73.27	26.73	9.25	10.88	29.08	47.81	2.98	1.74	0.58	1.98
Potatoes.....	76.95	23.05	6.01	11.74	3.41	78.15	0.69	1.88	0.51	2.06
Corn meal and bran.....	12.10	87.90	4.09	15.45	6.61	68.46	5.39	2.47	1.38	1.18
Mixed feed*.....	9.95	90.05	5.32	27.24	7.86	52.05	7.53	4.36	1.35	1.66

*6 parts wheat bran, 4 parts corn meal, 3 parts each of cottonseed and linseed meals (by weight).

The mixed silage kept poorly. It possessed a more disagreeable and penetrating odor than did the corn silage and it proved very unpalatable to some cows. Indeed two, whose records would otherwise have been used, ate too little silage to afford trustworthy data regarding its value. The other two ate it heartily and appeared to relish it. The condensed records appear in the appendix (Article VII of "Dairying"), following those pertaining to the article on "Studies in Methods of Experimental Feeding Trials," under the headings:

VII. Feeding records of the individual cows.

VIII. Records showing production and same per unit for each individual.

IX. Difference tables (*a*) Silages, (*b*) Silage vs. Potatoes.

2. CORN SILAGE VS. A SILAGE MADE FROM COWPEAS AND SOJA BEANS.

Cow peas and soja beans were grown on experimental plots on the station farm in the summer of 1895. The green material as it went into the silo contained on the dry basis 23 per cent. of crude protein. Corn silage averages about 11 per cent. of the same ingredient. A feeding test of the two silages, one relatively rich, the other relatively poor in protein, was designed. The mixed silage lost very heavily of its protein in the silo however and came out hardly richer in that ingredient than was its competitor. The reasons for this loss are not clear. The corn silage in another portion of the same silo kept nicely. The test became therefore one between two silages derived from very different crops, but of much the same chemical composition.

The data obtained in this trial with two cows expressed as percentage differences is shown in the following table, condensed from that given in the appendix.

The table shows increase or decrease (expressed as percentages, total=100) in dry matters eaten, in milk, total solids and fat given, and in products per 100 pounds of dry matter, both in the total and in the experimental portions of

the rations, when a ration containing a silage made of cowpeas and soja beans replaced one containing corn silage (nutritive ratios, probably about 1:6.5).

SUMMARY OF DIFFERENCE TABLES IX. (*a*) (APPENDIX.)

Dry Matter.	Dry Matter in Experimental Fodder.	Quantity of Milk.	Total Solids, per cent.	Fat, per cent.	Quality of Total Solids.	Quantity of Fat.	PRODUCT PER 100 LBS. OF DRY MATTER.					
							Entire Ration.			Experimental Fodder.		
							Milk.	Solids.	Fat.	Milk.	Solids.	Fat.
+2	+7	—6	+4	+9	—2	+2	—1	—7	—2	—28	—18	—23

The results indicate that:

1. The cows on the mixed silage ration ate more dry matter, but made less and better milk. Similar amounts of total solids and fat were made on each ration.

2. Much less milk and milk products were made on the mixed silage in proportion to the dry matter eaten.

3. The mixed silage was but little richer than the corn silage, notwithstanding it was made from leguminous plants. It cost more to grow and to harvest, and gave less fodder to the acre. It was distasteful and of a disagreeable odor.

4. The gain observed in quality is largely due to the analyses of single samples taken upon the same dates. Both samples and analyses, however, are felt to be trustworthy. The gain is probably attributable to a decided shrinkage in milk yield occuring coincident with the change of ration. A distinct though less noticeable gain in quality appears, however, even though these samples be discarded. Notwithstanding this observation, a test with but two cows, well along both in lactation and in calf, fed during only three periods, thus admitting of but two comparisons, is far from conclusive. The shrinkage in milk is probably an important factor in the change observed.

Since no digestion experiments have been made upon cowpea and soja bean silage, so far as the writer can learn, the comparison of digestible dry matters, etc. with production must of necessity be omitted.

Cowpeas and soja beans have been grown in New England to some extent. The former crop has sometimes done well in Connecticut,* but seldom, if ever, in Vermont.† The latter crop has proved quite successful on the station farm‡ for several years, and has been grown on a large scale at the

*Rpts. Storrs Exp. Sta., 1 (1888), pp. 96-101; 3 (1890), pp. 17-18; 8 (1895), pp. 105-106; 9 (1896), pp. 210-213.

†Rpts. Vt. Exp. Sta., 1 (1887), pp. 73-78; 9 (1895), p. 198.

‡Rpts. Vt. Exp. Sta., 7 (1893), p. 118; 8 (1894), p. 168; 9 (1895), p. 198.

Massachusetts station.* No feeding trial of a mixture of the two crops either green, hayed or ensiled, has been reported hitherto.†

Results obtained at other stations in feeding silage of each may be concisely stated as follows:

Cowpea silage. "It was readily eaten by steers."...The dry matter proved to be a little less and the protein a little more digestible than in corn silage.‡ "The vines make an excellent quality of silage, and the stock eat it readily... If they can be cured for hay we think it would pay better."‖

Soja bean silage. "Soja bean silage has been fed in our stable long enough to give assurance of its value. For milch cows it has seemed to arrest the natural decline in yield for a time when fed after a long period on corn silage. This may have been partly due to other causes, or changes in grain and approach of spring." The dry matter proved less and the protein more digestible when fed to goats than does the average corn silage when fed to cows. Two steers fed soja bean silage following corn silage "continued to gain at a rate but little slower."§

"Corn and soja bean silage (2:1) proved equal if not superior to hay in producing a yield of milk of equal quality at less cost."¶

Silage from soja beans was eaten by steers much less readily than that from cowpeas. Its "digestibility...corresponds closely to that of clover hay."**

3. CORN SILAGE VS. POTATOES.

Potatoes yielded remarkably well in 1895, and prices during the following winter were phenomenally low. Many farmers fed them out to stock, and the question arose as to their adaptability to the purpose, and their effect not only upon the quantity of milk but upon the quality of the butter.

Six cows were chosen for this test, and fed experimentally from Feb. 24 to May 11. Owing to the misunderstanding already mentioned, the potatoes were fed for thirty-nine instead of for twenty-eight days, and the rapid approach of warm weather prevented the full time being accorded to the final silage period. The feeding and laboratory records shown in the appendix have been so calculated therefore as to render each period comparable with the final shortened period.

The data obtained in this trial with six cows expressed as percentage differences is shown in the following table, condensed from that given in the appendix.

*Rpts. Mass. (Hatch) Exp. Sta., 4 (1891), p. 9; 5 (1892), p. 152; 6 (1893), p. 12; 7 (1894), pp. 13-14; 8 (1895), pp. 34-36; 9 (1896), pp. 9 and 15; Buls. 7 (1890), p. 16; 18 (1892), pp. 101-104.

†An analysis of such a silage is given in Rpt. Mass. (State) Exp. Sta., 8 (1890), pp. 129-130.

‡Bul. Ill. Exp. Sta., 43 (1896), pp. 189-192.

‖Bul. Ala. (Canebrake) Exp. Sta., 9 (1890), p. 5.

§Bul. N. C. Exp. Sta., 87 d (1892), p. 15; do. 93 (1893), pp. 41-42.

¶Rpt. Mass. (State) Exp. Sta., 11 (1893), pp. 15-35.

**Bul. Ill. Exp. Sta., 43 (1896), p. 195.

The table shows the increase or decrease (expressed as percentages, total=100) in dry matters eaten, in milk, total solids and fat given, and in products per 100 pounds of dry matter both in the total and in the experimental portions of the rations, when a ration containing potatoes replaced a ration containing corn silage.*

SUMMARY OF DIFFERENCE TABLES IX. (*b*). (APPENDIX.)

Dry Matter.	Dry Matter in Experimental Fodder.	Quantity of Milk.	Total Solids per cent.	Fat, per cent.	Quantity of Total Solids.	Quantity of Fat.	PRODUCT PER 100 LBS. OF DRY MATTER.					
							Entire Ration.			Experimental Fodder.		
							Milk.	Solids.	Fat.	Milk.	Solids.	Fat.
+10	+23	+2	0	+1	+2	+3	−11	−11	−12	−32	−33	−34

The outcome of these tests seems to justify the following interpretation:

1. The cows ate more freely of the potatoes than of the silage, and while on the potato ration consumed more dry matter, yet in five out of six cases they made no more milk, and in one case but little more. The milk did not change in quality, and essentially equal quantities of total solids and fat were produced on each ration.

2. Since increased production did not follow the more hearty eating, a pound of dry matter in the form of potatoes was less effective than a similar amount of dry matter in the form of silage.

3. Potatoes at 15 cents a bushel are more costly as stock food than is silage. When fed upon the farm the fertilizing ingredients are retained. This is a small but appreciable item. If one has sufficient silage or fodder, it is probably better practice to sell potatoes even at low prices rather than to feed them. Their effect upon the quality of the product should be remembered in this connection.

The only investigations by American stations touching the value of potatoes in animal feeding appear in the publications of the Wisconsin, Iowa and Minnesota stations. These stations report that "one pound corn meal was worth nearly four and a half pounds of (cooked) potatoes" for feeding hogs;† that potatoes are more valuable pound for pound for fattening purposes than any of the root crops;" and "that for dairy stock it is doubtful, when foods are as cheap as they are at present (Minnesota, 1896), whether it would pay to feed very large quantities of potatoes, because a dairy ration necessarily requires more protein than a fattening ration."‡ The Iowa experiment concerned the quality of the butter rather than the quantity of the product, and will be referred to in the next article, which, among other things, considers the quality of the butter made from potatoes.

*The nutritive ratios cannot be stated even approximately.
†Rpt. Wis. Exp. Sta., 7 (1890), p. 59.
‡Bul. Minn. Exp. Sta., 42 (1895), pp. 92-95.

III. THE EFFECT OF FOOD UPON THE QUALITY OF BUTTER.

It has been noted both in practical experience and as a result of experimental inquiry that the character of the butter made on different rations is sometimes affected more or less decidedly by changes in feeding. For instance, certain foods have been observed to produce hard, tallowy butters, while others have rendered the product soft and oily. The grain and the color are most open to modification in this matter, while flavor, provided the foods making up the ration are of good quality, is less often influenced.

Several tests of the effect of foods upon the quality of butter have been made in this and other countries, the New Hampshire and Texas stations in particular having contributed much valuable information upon this subject.* The results have not been entirely uniform and many discrepancies are to be found. A few points, however, seem fairly well settled, but their relation to the chemistry and physiology of milk secretion and to the composition of the various butter fats is far from clear. Our present knowledge touching the factors involved in this matter is too meagre to warrant one in making many positive statements regarding the effect of food upon the quality of butter.

The results of two series of observations made during the past two springs are presented herewith as of possible use in future generalizations. The experiments covered not only the effects of food upon the character of the butter but also upon the completeness of the churning. The results may be concisely summarized under their respective numbers and headings as follows:

1. SUMMARY.

2. *Effects upon butter.* Butter made from a ration containing large amounts of potatoes was of poor quality, tended to be salvy and did not keep well. It showed upon chemical analysis a medium amount of volatile acids but a very low iodine number.

Butters made from three hay and silage rations containing respectively large amounts of corn and bran, of Atlas gluten meal, and of cottonseed and linseed meals were scored by experts essentially alike. The butter made upon the rations containing relatively large amounts of Atlas gluten meal was judged by the station dairyman to be on the whole a shade inferior to the others, particularly in grain. The only marked difference developed on chemical analysis concerned the iodine number, which in the Atlas butter was uniformly high, indicating, probably, an increased percentage of olein.

3. *Effects upon churning.* The creams from the milks made on the Atlas ration invariably churned less exhaustively than did those made upon either the corn and bran or the cottonseed-linseed rations, all other conditions being equalized. No plausible reason other than that of food effect presents itself, yet the writer feels unwilling as yet to assert that the Atlas ration was at fault in the matter.

*An excellent resume of experiments upon the subject is given by rFear in Agl. Sci. 7 (1893), 4, pp. 120-141.

2. EFFECTS UPON BUTTER.

In the course of the experiments described in the preceding two articles a study was made of the effect of the various rations upon the quality of the butter. The butters were subjected not only to the analyses of the chemists, but to the scrutiny of experts. An attempt was made also in some cases to determine what effect, if any, the varying food of the animals had upon the losses occurring in butter-making. It should be said that the determination of food effects upon the quality of butter, if any, was kept secondary to the main objects of the experiments as outlined on previous pages. The experimental feeding scheme of the winter of 1896-97 was such that there was no continuity of the animals upon a single ration. The cows which formed the Atlas group on a given date were in a short time scattered among all three groups, from which in turn the Atlas group would be recruited. For example, on April 13, fifteen cows were eating Atlas rations. Ten days later nine of these were on cottonseed-linseed rations, three on corn and bran rations, while three, joined with others which had been turned from corn and bran, continued upon the Atlas. It is thought that in some respects this shifting of the animals among the rations was an advantage rather than the reverse, inasmuch as it tended to minimize the effects of individuality and of differing lactation periods. The rations used in these experiments were:

1. Hay, silage, mixed feed No. 1 (6 parts wheat bran, 4 parts corn meal, 3 parts cottonseed meal, 3 parts linseed meal, by weight).
2. Hay, potatoes, mixed feed No. 1.
3. Hay, silage, equal parts each of corn and bran.
4. Hay, silage, corn, bran, and Atlas gluten meal. (In some cases 3 parts bran, 2 parts corn meal, and 4 parts Atlas gluten meal were fed, and in others 1 part each of corn and bran, and 6 parts of Atlas gluten meal were fed).
5. Hay, silage, mixed feed No. 1 (same as ration 1).

The first two rations were fed to six cows during three months in the late winter and spring of 1896; the last three rations were fed to thirty-four cows during twenty-four weeks, November, 1896, to May, 1897. The test of the effect of these latter rations upon the quality of the butter, however, was confined to two months in the spring of 1897.

The milk produced on each of these rations was separately handled from cow to butter tub, each being creamed, ripened, churned and worked by itself. In the course of the investigations the following numbers of samples of butters were taken for analysis: Ration 1, 1; 2, 2; 3, 22; 4, 25; 5, 19. The samples from the last three rations were afterwards combined in sets of three for analysis.

Sample packages of butter representing each of these rations were sent to Boston experts for scoring.* The packages sent in the spring of 1896 were

*The thanks of the Station are due to Messrs. Orin Douglas, J. Harvey White, and Bartlett Bros. for their kindness in the matter of scoring the butter.

unfortunately lost in transit, and when they finally arrived, some weeks later, were in too poor condition to furnish reliable data. The following tables give the scorings upon the butters representing the last three rations:

SCORING OF BUTTERS.

	April 19.				May 10.			
	Standard.	Corn and bran.	Cottonseed-linseed.	Atlas.	Standard.	Corn and bran.	Cottonseed-linseed.	Atlas.
Flavor	50	43	43½	44	45	36	36¼	37
Grain	25	24	25	25	30	30	30	30
Color	10	9¾	9¾	9¾	15	15	15	15
Salt	10	10	10	10	10	9½	10	10
General Appearance	5	5	5	5				
	100	91¼	93¼	93½	100	90½	91½	92

The judges, it will be observed, used different score cards at the two different times. The differences between the butters as judged by the scoring are too slight to lay stress upon. It is notable, however, that the butter made from the Atlas ration was judged by these gentlemen to be as good as either of the others. In fact, it scored a trifle higher in flavor than did either of the others. The butter was scored when about a week old. It was the judgment of the station dairyman, who had charge of the handling of the milk and butter throughout, that in the long run the Atlas butter seemed to have a somewhat less satisfactory body than did the others. It appeared to be more oily, and to be, on the whole, a shade inferior to the others in flavor. The analytical samples, taken from March 13 to May 13, were stored in the ice house, and were all carefully examined by the station dairyman on July 28, just prior to analysis. All showed age but none were bad. The butters representing the corn and bran rations appeared to hold up in quality a shade better than did the others.

It was the judgment of several good dairymen to whom the potato butter of the previous spring was presented, that it was of inferior quality to that made upon the silage ration, that its grain had suffered and that it was somewhat salvy. Essentially the same judgment was passed by the station dairyman as the result of careful observation throughout the course of the test.

The various butter samples were analyzed for volatile acids, iodine absorption number, and the 1897 samples were likewise tested for melting point and hardness as determined by Parsons' method.*

*Bul. N. H. Exp. Sta., 13 (1891) p. 8. The method worked nicely and duplicates agreed within 1 mm. It was found that the dimensions of the rod (upon which considerable stress is laid in the bulletin cited) is a matter of little moment, and that duplicate results were obtainable with rods of very diverse lengths provided their weights and the distance of falls were uniform.

AVERAGES OF ANALYSES OF BUTTERS FROM VARIOUS RATIONS.

Character of Ration.	Number of analytical samples.	Volatile acids.‖	Iodine absorption number.	Melting point.	Hardness.§
1. Silage	1	28.9	31.70		
2. Potato	2	28.7	26.00		
3. Corn and bran	7	30.7	27.48	33.3	12.1
3-4. Corn and bran and Atlas*	1	29.7	34.92	32.8	17.6
4. Atlas	5	29.4	37.14	33.1	12.0
4-5. Atlas and cottonseed-linseed†	1	30.3	36.74	33.5	9.9
5. Cottonseed-linseed‡	8	32.5	30.04	33.7	12.4

*Made up of one sample corn and bran butter and two samples of Atlas butter.

†Made up of two samples of Atlas butter and one sample of cottonseed-linseed butter.

‡Although differently designated, this ration is essentially similar to No. 1.

‖Expressed as c. c. of tenth-normal alkali used to neutralize the volatile acids from 5 grams of butter fat.

§Expressed as mm. of penetration of a 10 gram rod falling approximately 3 feet.

A study of these figures indicates that volatile acids varied within comparatively narrow limits. The cottonseed-linseed butter made in 1897 ran higher in this respect than did the others, but since the same ration gave results which were at the other extreme in 1896, very little stress can be laid upon the difference. When fed in large quantities the cottonseed products have been found to decrease the volatile acids and to raise the melting point of the butter. In these tests, however, the dry matter of the cottonseed meal comprised only 10 per cent. of the total dry matter, and was but one of six materials fed.

But little difference was found in melting points and hardness. The iodine absorption number, however, was decidedly influenced by the various rations, being very low in the potato butter and very high in the Atlas butter. The gradations occurring in the mixed samples numbered 3-4 and 4-5 are very suggestive. The iodine numbers of the individual samples are as follows:

Corn and bran; 28.52, 27.66, 26.96, 27.19, 27.14, 27.11, 27.80.

One sample corn and bran, two samples Atlas gluten } 34.92.

Atlas gluten; 37.02, 37.10, 36.47, 36.71, 38.38.

Two samples Atlas gluten, one sample cottonseed-linseed. } 36.74.

Cottonseed-linseed; 31.35, 30.80, 29.49, 30.00, 28.86, 29.10, 30.38, 30.31.

The butters made from the various rations grade from low to high in iodine number as follows:

Very low. Potato, corn and bran.

Medium. Cottonseed-linseed and silage.

High. Atlas gluten meal.

It is usually considered that a high iodine number indicates an increased per cent. of olein, although this assumption is disputed by some. The connection of this figure with market quality is not clear. In the present experiments the potato and the Atlas butters, at the extremes in iodine numbers, were judged to be on the whole the most salvy. Increased amounts of olein would tend to soften the butter.

It was remarked at the outset that results in this line of experimental work are very discordant, but that on a few points there seems to be some measure of agreement. Touching the quality of potato butter, it is stated by Fleischmann* that "potatoes if fed in quantity greater than 33 lbs. per head make butter hard,"† and by Wilson *et. al.*‡ that "high grade butter cannot be made when cows are eating 10 pounds of raw potatoes a day; that butter from potato feeding on dry rations is colorless and lacks in keeping qualities; that cows will eat as much as 50 pounds of potatoes a day by gradually increasing them, but will eat less day after day, until 10 pounds a day is reached."

The quality of butter from Atlas gluten meal feeding does not appear to have been hitherto investigated. Morse§ has noted the influence of corn meal in depressing and of ordinary‖ gluten meal in increasing the iodine number.

3. EFFECT UPON CHURNING.

Attention has already been called to the fact that the milks representing these various rations were handled separately throughout. The DeLaval, Sharples and United States separators were used at different times. There were some variations in the quality of the skimming with these machines. The different milks in the same machine, however, appeared to be handled with equal efficiency, or in other words, there appeared to be no more loss in skimming the milk made upon one ration than upon another. A marked difference, however, was observed in the character of the churning of the creams. The following table gives the averages of the more important details:

AVERAGES OF DETAILS OF CHURNING CREAMS FROM VARIOUS RATIONS.

Character of Ration.	Number of churnings.	Temperature at end of churning.	Time of churning.	Cream.	Butter.	Per cent. fat in buttermilk.
		min.	°F.	lbs.	lbs.	
Corn and bran	19	58.5	31	40	18	0.18
Cottonseed-linseed	22	58	28	63	29	0.17
Atlas gluten meal	14	57	20	52	23	0.50

*Molkereiwesen, p. 621.

†This observation accords with the testimony of the chemical analysis in the present case, but not with the judgment of the station dairyman.

‡Bul. Iowa Exp. Sta., 17 (1892), p. 377.

‖It should be remembered that the Atlas meal is not strictly a gluten derived from corn only, but a distillery by-product containing other grain than corn. See footnote, page 147.

§Bul. N. H. Exp. Sta., 16 (1892).

The concentration of the cream was quite uniform throughout the tests, and the churn used was of such a size as would handle properly the amounts of cream churned. There were, however, more or less differences in the ripeness of the creams, and in temperatures and times of churning during the test. Since these factors are frequently found to be of importance as determining the exhaustiveness of churning, the following table is presented, showing the effects of these differences upon the per cents. of fats in buttermilks.

PER CENTS. OF FAT IN BUTTERMILKS AS MODIFIED BY ACIDITY, TEMPERATURE AND TIME OF CHURNING.

Character of Ration.	Acidity.			Temperature.			Time.		
	Sweet.	Medium.	Full.	54°-57° F.	58°-59° F.	60°-62° F.	10-19 Minutes.	20-29 Minutes.	30 Minutes and upwards.
Corn and bran	0.20	0.23	0.13	0.17	0.17	0.24	0.19	0.17	0.15
Cottonseed-linseed	0.15	0.22	0.14	0.16	0.19	0.16	0.11	0.17	0.19
Atlas gluten meal	0.81	0.34	0.48	0.27	0.71	0.75	0.55	0.49	0.35

The creams representing the corn and bran and the cottonseed-linseed rations churned well, and the variations in acidity, temperature and time of churning seemed to have little influence upon the result. The cream representing the Atlas ration churned less exhaustively and more promptly than did those of the other rations. This statement is true both as regards the average and the individual churnings. But twice in fourteen times did the Atlas cream churn as exhaustively as did the average cream from the other rations, while not once in forty-one churnings was as poor work done with the cream representing the corn and bran or the cottonseed-linseed rations as was done on the average with the Atlas cream. The well known effects of sweet cream, high temperature and rapid churning are shown very plainly with the Atlas creams; yet even under the best of conditions the Atlas cream did not churn exhaustively. This is either a most remarkable series of coincidences or else some cause other than those cited above is responsible. It should be remembered in this connection that the cows were shifting back and forth in their rations, and that, therefore, the result cannot be due to the individuality of the animals.

The entire creamery work from beginning to end was in the hands of the station dairyman, and every possible care was taken to maintain precisely similar conditions for each cream. In most cases the creams were churned upon the same day; in a few cases, two on one day and one on the day following. The uniformity of these results is very striking, yet the writer does not feel warranted in declaring unreservedly the causal relation of the Atlas

ration. It must be said, however, that no more plausible reason has as yet suggested itself. It is expected in our further feeding trials to continue investigations along this line.

IV. RECORD OF THE STATION HERD FOR 1895-96.

The record of the dairy herd of the Vermont station has been printed in several of its previous publications.* The records of the year Nov. 1, 1895-Oct. 31, 1896 are more full and complete than any previously obtained and the tabulations on pages 182-183 show for each cow not only the production of milk, total solids, fat and butter, but also the cost of the food eaten per 100 pounds of milk and per pound of fat and of butter, the cost of the total food eaten, of the purchased grain, the net proceeds from butter sales, and the value of the fertilizing ingredients in the fodders and feeds eaten.

The average production of the entire herd for successive years has been very uniform, having been in 1892, 355 pounds; 1893, 330 pounds; 1894, no record; 1895, 325 pounds; 1896, 324 pounds. The first two records were obtained with the herd slaughtered early in 1894 because of tuberculosis; the latter two represent the herd bought mainly in 1894. The present herd is twice the size of its predecessor, and has been kept free from tuberculosis, but has been considerably troubled by abortion and failure to breed, both of which maladies have seriously curtailed production.

The registered Ayrshires and Jerseys have A. R. and A. J. C. C. numbers against their names; all other animals are high grade Jerseys. Many of the cows have had higher butter records than those given above (see eighth and ninth reports).

Cows whose names are marked § entered the herd January 21; those whose names are marked ¶ were at the farm less than nine months

The "cost of food" is reckoned from prices paid for grain (corn $15, bran $13, cottonseed meal $24, linseed meal $21, Atlas gluten meal $16, corn oil cake $20, cottonseed bran $17); hay $10.50, silage, corn fodder, soiling crops, roots, etc., $3.00; pasturage $5 per animal. The figures for hay, silage, pasturage, etc., are based on the judgment of many successful Vermont dairymen as reported to the station. The average cost of food for 100 pounds of milk and for a pound of butter as stated in the table is obtained by dividing the total by 37, thus giving each cow the same value in the average, be she good, bad or indifferent. *As a herd* the average cost of food for 100 pounds of *herd* milk was 77.3 cents and for a pound of butter, 13 cents ($42.00 \div 5431 \times 100$ and $42.00 \div 324 \times 100$.)

*Bul. Vt. Exp. Sta., 33 (1893); Rpts. do. 6 (1892) pp. 119-121; 7 (1893), pp. 82 83; 9 (1895), pp. 187-192.

RECORD OF THE HERD OF THE VERMONT AGRICULTURAL EXPERIMENT STATION FOR THE YEAR NOV. 1, 1895-OCT. 31, 1896.

Cow.	Approximate weight.	Age Nov. 1, '95.	Calved 1895.	Calved 1896.	Days in milk.	Milk.	Total solids.	Fat.	Total solids.	Fat.	Butter.
						lbs.	%	%	lbs.	lbs.	lbs.
Acme 5th, 10342 A. R.	930	6	Oct. 4	Sept. 19	310	8183	12.90	4.04	1055.5	330.9	386.1
Atalanta, 10777 A. R,	870	6	Sept. 25	Sept. 13	316	7312	12.44	3.69	909.7	269.7	314.7
§Besette of Brondale, 99766 A. J. C. C.	800	4	———	†Jan. 15	281	5422	14.81	5.45	802.5	295.5	344.8
Bess	920	9	Oc.24'94	Mch. 6	277	6387	14.71	5.45	939.6	348.0	406.0
Bettie	930	7	*July 19	Farrow	360	6502	14.07	5.22	914.8	339.0	395.5
Brownie	860	6	Nov. 11	"	355	7357	14.61	5.34	1075.3	393.0	458.5
Clover	1000	8	Sept. 24	"	366	5768	16.17	6.28	932.7	362.4	422.8
§Cressy of Brondale, 75974 A. J. C. C.	850	7	———	†Jan. 15	281	4796	14.32	5.35	686.9	256.5	299.2
Dandelion	780	6	Oct. 15	Farrow	366	5546	14.83	5.64	822.4	312.6	364.7
Dora	820	6	*Aug. 17	Sept. 21	340	3613	15.56	6.04	562.3	218.1	254.5
Effie	830	7	Sept. 7	*July 9	366	5004	13.81	4.49	690.8	224.7	262.2
Eulalie	1060	6	Dec. 2	Farrow	333	6893	14.31	4.93	986.4	339.5	396.1
Fairie	790	6	Mch. 28	Mar.6'97	366	4882	15.29	5.92	746.6	288.8	337.0
Fanny	990	6	Farrow	Sept. 24	277	2854	14.15	5.14	403.8	146.6	171.0
Flora	970	6	Aug. 12	Aug. 27	283	3721	14.09	5.05	524.1	188.0	219.4
Flox	900	5	Jan. 15	*Jan. 1	366	5973	14.25	4.97	851.2	296.8	346.3
Golden Rod	950	4	Oct.5 '94	Jan. 7	308	5399	15.80	6.21	852.8	335.1	391.0
Goldie	980	9	June 21	June 29	310	4375	14.88	5.38	651.1	235.2	274.5
Idarella	870	5	Oct. 28	Farrow	366	5728	14.70	5.32	842.1	305.0	355.8
Jeannie	830	6	*Nov. 1	"	360	7461	13.75	4.79	1026.2	357.8	417.4
Jersey Lily	860	4	Oct. 18	Mar.6'97	366	5455	15.53	5.81	847.4	316.9	369.7
Jessaline	1080	5	*Apr. 18	June 26	353	3400	13.04	4 59	443.4	156.2	182.2
Jessie	850	6	Nov. 28	Oct. 29	268	5236	15.49	5.86	810.8	306.8	357.9
Julia	840	6	Apr. 9	Farrow	366	4582	15.88	6.00	727.4	274.8	320.6
Kinkora	790	6	*Nov. 18	"	355	3656	15.27	5.76	558.1	210.5	245.6
Kittie	870	6	Sept. 24	Aug. 25	297	4029	14.95	5.30	602.4	213.4	249.0
§Lady Le Brocq	800	6	*Sept. 20	*July 4	253	3622	16.12	6 24	583.8	226.1	263.8
Maizie	940	9	July 29	Nov. 14	283	3295	14.15	5.05	466.3	166.3	194.0
Marjory	800	7	†Jan. 15	June 12	362	5344	14.57	5.36	778.4	286.7	334.5
§Max Belle, 108966 A. J. C. C.	720	3	———	†Jan. 15	285	3596	16.12	6.25	579.5	224.7	262.1
§Minta Bella, 85578 A. J. C. C.	680	4	———	†Jan. 15	285	4726	15.39	6.25	727.2	295.3	344.5
Nancy B., 9581 A. R.	1040	8	July 18	Aug. 29	293	6068	13.08	4.06	793.5	246.6	287.7
¶Nett, 10169 A. R.	1000	7	Sept. 24	†Sept. 1	262	6923	13.06	4.05	903.9	280.6	327.4
Portelette	870	7	Dec. 6	Mar.6'97	309	7507	13.22	4.37	992.7	328.4	383.1
Red Top	900	6	Oct. 26	Oct. 18	300	6694	13.52	4.59	904.9	306.9	358.1
Regina	800	6	Dec. 26	Farrow	323	6572	12.92	4.05	849.2	266.1	310.5
Rowena	830	4	Sept. 18	"	366	7048	13.87	4.67	977.4	329.0	383.8
Average of 37 cows					322	5431	14.34	5.12	779.0	277.8	324.1
Daisy	750	2	———	Jan. 19	285	3111	15.04	5.43	467.8	169.0	197.2
Helena	650	2	———	May 20	160	1633	14.61	5.23	238.6	85.4	99.7
Lena	650		Oct. 23	Killed	105	1839	15.62	5.71	287.3	105.0	122.5
Rena Myrtle	1100	8	Farrow	Sold	173	958	13.04	4.14	124.9	39.7	46.3
Rhoda	850	6	July 30	Killed	208	3125	15.03	5.39	469.7	168.5	196.6
Salida	780	2	———	May 20	160	1866	14.31	4.86	267.0	90.6	105.7

*Aborted.

†Approximate.

HERD RECORD—Continued.

Cows.	Total cost of food.	Total cost of purchased grain.	Cost of food for 100 lbs. of milk.	Cost of food for 1 lb. of fat.	Cost of food for 1 lb. of butter.	Proceeds from butter sales.	Value of fertilizing ingredients in food.
	$	$	cts.	cts.	cts.	$	$
Acme 5th, 10342 A. R.	47.69	14.06	58.3	14.5	12.4	88.80	22.78
Atalanta, 10777 A. R.	45.39	15.42	62.1	16.8	14.4	72.38	20.13
§Besette of Brondale, 99766 A. J. C. C.	28.27	8.53	52.1	9.5	8.2	79.30	11.57
Bess	44.89	13.88	70.3	13.0	11.1	93.37	22.04
Bettie	44.30	14.61	68.1	13.1	11.2	90.96	22.25
Brownie	43.95	13.43	59.7	11.2	9.6	105.43	20.47
Clover	48.97	14.93	84.9	13.5	11.6	97.24	23.53
§Cressy of Brondale, 75974 A. J. C. C.	31.99	9.11	66.7	12.5	10.7	68.81	14.99
Dandelion	41.89	13.61	75.5	13.4	11.5	83.87	19.97
Dora	36.28	14.80	100.4	16.6	14.3	58.51	16.78
Effie	43.29	16.68	86.6	19.3	16.5	60.30	21.91
Eulalie	48.90	16.15	70.9	14.4	12.3	91.10	22.88
Fairie	41.13	15.94	84.6	14.2	12.2	77.50	18.09
Fanny	39.58	14.07	138.7	27.0	23.1	39.34	17.54
Flora	40.48	14.73	108.8	23.8	18.4	50.46	17.96
Flox	46.45	20.29	77.8	15.6	13.4	79.64	26.14
Golden Rod	46.62	17.78	86.3	13.9	11.9	89.92	23.70
Goldie	47.28	14.79	108.1	20.1	17.2	63.13	18.99
Idarella	43.72	15.44	76.3	14.3	12.3	81.82	19.59
Jeannie	45.48	17.67	61.0	12.7	10.9	96.00	20.16
Jersey Lily	43.16	11.96	79.1	13.7	11.7	85.03	20.51
Jessaline	43.49	14.58	127.9	27.8	23.9	41.90	18.69
Jessie	43.35	13.56	82.8	14.1	12.1	82.29	20.88
Julia	43.21	15.07	94.3	15.7	13.5	73.73	18.93
Kinkora	39.80	13.83	108.9	18.9	16.2	56.48	17.31
Kittie	46.41	13.60	115.2	21.6	18.5	57.26	17.73
§Lady Le Brocq	32.96	11.83	91.0	14.6	12.5	60.67	16.87
Mairie	38.80	13.52	117.8	23.3	20.0	44.63	17.82
Marjory	46.60	16.47	87.2	16.2	13.9	76.94	21.07
§Max Belle, 108996 A. J. C. C.	30.99	9.94	86.2	13.8	11.8	60.28	14.63
§Minta Bella, 85578 A. J. C. C.	32.26	10.41	68.3	10.9	9.4	79.22	15.23
Nancy B., 9581 A. R.	45.06	15.04	74.3	18.3	15.7	66.16	20.95
¶Nett, 10169 A. R.	45.64	12.37	66.0	16.3	14.0	75.30	22.18
Portelette	45.13	15.34	60.1	13.7	11.8	88.10	20.36
Red Top	46.59	13.96	69.6	15.2	13.0	82.36	20.75
Regina	44.45	14.55	70.9	16.7	14.3	71.41	21.88
Rowena	49.53	14.33	70.3	15.2	13.0	88.26	23.61
Average of 37 cows	42.00	14.22	82.9	16.1	13.8	74.51	19.74
Daisy	29.36	11.36	94.4	17.4	14.9	45.35	12.90
Helena	15.57	4.74	95.3	18.2	15.6	22.93	5.45
Lena	15.09	5.39	82.0	14.4	12.3	28.17	7.98
Rena Myrtle	19.86	3.50	207.3	50.0	42.9	10.65	10.28
Rhoda	28.74	10.56	92.0	17.1	14.6	45.21	14.56
Salida	15.51	4.82	83.1	17.1	14.7	24.31	5.42

The figures showing "cost of 100 pounds of milk" and "cost of one pound of butter" include only the cost of food as laid down in the barn ready for feeding. They do not include cost of feeding, caring for cows, making and marketing butter, depreciation of plant, interest on investment, etc. It should be noted, however, that several items, which may be very properly considered an offset to these unincluded expenses, do not figure in the table. It should be remembered:

1. That "roughages" are rated at figures sufficiently liberal to more than cover the cost of raising and harvesting them in average seasons.
2. That the fertilizing ingredients in the food are worth 47 per cent. of the rated cost (at market prices for the same plant food of similar availability in the form of commercial fertilizers).
3. That the fertilizing ingredients in the purchased grain are worth 61 per cent. of its market price.
4. That 6 tons of butter remove but $2.48 worth of plant food from the farm.
5. That the increase of the herd and the sales of calves and fat cows are further items not considered above.
6. That the skim-milk, at 18 cents per hundred (which was its feeding value as found in the experiments of 1896), with dressed pork at 4½ cents, was worth $324.00 as food.

Twenty-eight of the individual cows whose records appear in the preceding table, together with two others, formed the herd of which the record was published in our last report. Comparing the records of the two years we find that twelve cows gave more, two, the same and fourteen, less milk the second year than they did the first; that twelve gave more, two, the same, and fourteen, less butter in 1895-96 than in 1894-95; while eleven gave better, ten, poorer, and seven, the same quality of milk in the latter as compared with the former year. The average for the twenty-eight cows shows almost exactly the same production each year but at greatly reduced cost during the latter year.

AVERAGE RECORD OF TWENTY-EIGHT COWS FOR TWO YEARS.

Year	Pounds of milk.	Per cent. of fat.	Pounds of butter.	Cost of food.	Cost of purchased grain.	Cost of food per lb. butter.	Proceeds of butter sales.
1894-95	5616	5.02	329	$50.36	$18.92	16.2 cts.	$77.18
1895-96	5586	5.03	328	43.72	14.49	14.1	75.48

In spite of the fact that grain bills are cut down one-fourth the production remained uniform. Butter sold at an average price of 23 cents, as against 23½ cents the previous year. The price of grain was somewhat lower and there was actually much less fed, particularly in the summer.

AVERAGE RECORD OF THE ENTIRE HERD FOR TWO YEARS.

Year.	Pounds of milk.	Per cent. of fat.	Pounds of butter.	Cost of food.	Cost of purchased grain.	Cost of food per lb butter.	Proceeds of butter sales.
1894-95	5633	4.95	325	$50.06	$18.85	16.2 cts.	$76.40
1895-96	5431	5.12	324	42.00	14.22	13.8	74.51

Considering the trouble experienced with abortion and failure to breed, and also the diminished grain ration, it is thought that the record for 1895-'96 compares favorably with that of any year preceding.

The cows are grouped in the following table according to production and cost of production.

RELATIVE RANK OF THE INDIVIDUAL COWS IN PRODUCTION AND IN COST OF PRODUCTION.

Relative Rank.	Amount of Milk.	Amount of Butter.	Cost of Milk.	Cost of Butter.
1	*Acme*.....(2)	Brownie(16)	**Besette***.....	**Besette***.....
2	Portelette.....(7)	Clover.....(27)	*Acme*..... (2)	**Minta Bella***.....
3	Jeannie(30)	Jeannie.....(30)	Brownie.....(24)	Brownie.....(17)
4	Brownie(23)	Bess.....(1)	Portelette.....(7)	**Cressy***.....
5	*Atalanta*.....(6)	Eulalie.....(7)	Jeannie..... ...(30)	Jeannie.....(30)
6	Rowena.....(27)	Bettie.....(23)	*Atalanta*.....(8)	Bess.....(2)
7	*Nett*†.....(1)	Golden Rod.....(3)	*Nett*†.....(1)	Bettie(23)
8	Eulalie..(8)	*Acme*.....(6)	**Cressy***.....	Dandelion(14)
9	Red Top.....(21)	Rowena.....(29)	Bettie(18)	Clover.....(26)
10	Regina.....(15)	Portelette.....(14)	**Minta Bella***.....	Jersey Lily.....(7)
11	Bettie.....(19)	Jersey Lily.....(13)	Red Top.....(27)	**Max Belle***.....
12	Bess.....(4)	Dandelion.....(18)	Bess.....(4)	Portelette(13)
13	*Nancy B*.....(3)	Red Top.....(22)	Rowena(25)	Golden Rod.....(6)
14	Flox.....	Jessie.(2)	Regina.....(16)	Jessie.....(1)
15	Clover.....(29)	Idarella	Eulalie(5)	Fairie.....(8)
16	Idarella	Flox..... ...	*Nancy B*.....(3)	Eulalie.....(5)
17	Dandelion.....(25)	**Besette***.....	Dandelion.....(23)	Idarella
18	Jersey Lily.....(18)	**Minta Bella***.....	Idarella.....	*Acme*.....(10)
19	**Besette***.....	Fairie..... (15)	Flox....	Lady Le Brocqt .(4)
20	Golden Rod.....(17)	Marjory.....	Jersey Lily.....(15)	Red Top(27)
21	Marjory	*Nett*†.....(4)	Jessie.....(6)	Rowena (29)
22	Jessie.....(5)	Julia.....(12)	Fairie..... ...(10)	Flox.....
23	Effie.....	*Atalanta*.....(20)	Clover.....(29)	Julia.....(3)
24	Fairie.....(13)	Regina.....(25)	**Max Belle***.....	Marjory
25	**Cressy***.....	**Cressy***.....	Golden Rod.....(22)	*Nett*†.....(9)
26	**Minta Bella***.....	*Nancy B*.....(9)	Effie.....	Regina(25)
27	Julia(16)	Goldie.....(10)	Marjory	Dora..(11)
28	Goldie.....(14)	Lady Le Brocqt..(5)	Lady Le Brocqt..(11)	*Atalanta*.....(24)
29	Kittie	Effie.....	Julia.....(9)	*Nancy B*.....(16)
30	Flora..... ...(28)	**Max Belle***.....	Dora.....(19)	Kinkora.....(19)
31	Kinkora...(24)	Dora.....(8)	Goldie.....(21)	Effie.....
32	Lady Le Brocqt (10)	Kittie	Kittie	Goldie.....(12)
33	Dora.....(11)	Kinkora(19)	Flora...(26)	Flora.....(21)
34	**Max Belle***.....	Flora.....(26)	Kinkora.....(17)	Kittie.....
35	Jessaline.....(12)	Maizie(11)	Maizie.....(12)	Maizie.....(18)
36	Maizie.....(9)	Jessaline.....(17)	Jessaline.....(13)	Fanny.....(28)
37	Fanny.....(26)	Fanny.....(28)	Fanny.....(28)	Jessaline.....(15)

*First nine months of lactation only; this proves a disadvantage in the first two, and an advantage in the last two columns, and affects the relative ranks accordingly.

†Last nine months of lactation only; this proves an advantage in all the columns.

The figures in parenthesis indicate relative rank among thirty cows in the record of 1894-95, as shown in the last report. Italicized names are those of registered Ayrshires, black face names, those of registered Jerseys.

It should be noted that the cows Besette, Cressy, Max Belle, Minta Bella, Lady LeBrocq and Nett, were at the farm and in milk but about nine months. These were the first nine months of lactation with the first four, and hence the costs of milk and butter as stated in their cases is below the truth for the entire year The figures as stated for the last two cows named are probably above the truth, since their deaths in late summer and early fall, resulting from complications following milk fever, shortened the year, while, moreover, the record was of the latter part of lactation.

It is again shown that the Ayrshire cow is more successful as a milk maker than as a butter producer. As a general rule the cows making the most butter were the most economical producers. The larger cows, which ranked well in gross amounts of butter made, graded lower in most cases in economy of production, while the smaller cows which stood near the head in amount of

butter made, did not lose rank in the matter of cheap manufacture. In other words, the well-known fact that the smaller cow usually makes the cheapest butter is again demonstrated.

It is interesting to note relative ranks in the two successive years. Several continue without material change. Jeannie, Clover and Bettie, who were far to the rear in 1894-95, are in the forefront in 1895-96. The cows ranking at the head this year in butter product stood 16, 27 and 30, in a herd of 30 last year. Their vacation seemed to have given them renewed energy. Some of last year's better cows held much poorer positions this year. Fannie, Flora, Effie and Kinkora, having been in the rear guard for two years with little likelihood of improvement in the future, were sent to the block, their places to be supplied by the increase of the herd.

The following table shows extremes of quantity, quality, cost of production, etc., observed in the record.

EXTREMES OF PRODUCTION.

	Lowest amount for any cow.	Highest amount for any cow.	Ratio of lowest to highest.
Pounds of milk	2854 (Fairy)	8183 (Acme)	1 : 2.87
Per cent. of total solids	12.44 (Atalanta)	16.17 (Clover)	1 : 1.30
" " fat	3.69 "	6.28 "	1 : 1.70
Pounds of total solids	403.8 (Fanny)	1075.3 (Brownie)	1 : 2.66
" fat	146.6 "	393.0 "	1 : 2.68
" butter	171.0 "	458.5 "	1 : 2.68
Cost of feed	$36.28 (Dora)	$49.53 (Rowena)	1 : 1.37
" grain	$11.96 (Jersey Lily)	$20.29 (Flox)	1 : 1.70
" 100 pounds of milk	58.3 cts (Acme)	159.4 cts (Fanny)	1 : 2.73
" 1 pound of fat	11.2 cts (Brownie)	27.8 cts (Jessaline)	1 : 2.48
" 1 pound of butter	9.6 cts "	23.9 cts "	1 : 2.49
Value of butter product at actual selling price	$39.34 (Fanny)	$105.43 (Brownie)	1 : 2.68
Value of fertilizing ingredients in food	$16.78 (Flox)	26.14 (Flox)	1 : 1.56

No special effort was made to select or to feed the most economical ration or to force any cow to extraordinary production. Thirty-one of the thirty-seven cows were used in feeding experiments, were subjected to many changes of ration, and were fed in some cases distasteful, wasteful or ill balanced rations in the course of experimental work. Such changes are obviously disadvantageous to maximum production. While rations of many different nutritive ratios were fed, it is safe to say that few were as narrow as is the Wolff standard. It is more or less guess work to try to make an estimate when variations are so frequent and excessive, but probably the average would not be far from 1 : 7.5 to 1 : 8. Clearly the cows were not forced by excessive feeding to high production.

The following table shows the food eaten by each cow. All the cows were out to short pasture for about five and one-half months, were housed every night, fed twice daily the year round, grained during only a part of the summer, watered (in winter) twice, and turned out in the winter for from 20 to 35 minutes daily, except in extreme weather.

FEEDING RECORD, NOVEMBER 1, 1895—OCTOBER 31, 1896.

NAME OF COW.	*Hay.	Corn meal.	Wheat bran.	½ Cottonseed, ½ linseed.	Experimental meals.	Silage.	Corn fodder. (e)	Roots. (f)	Various green fodders. (i)	Hungarian and millet. (j)
Acme	1575	508	680	518	—	6087	2897	(g)3806	467	270
Atalanta	1873	359	878	60	(b) 302	6358	2853	21	448	337
(1) Besette	1097	590	615	—	(d) 10	3272	1787	(g) 111	342	369
Bess	1553	484	661	530	—	6902	3125	1130	307	365
Bettie	1550	447	655	620	—	6954	3318	21	349	325
Brownie	1882	771	790	60	(a) 227	6742	2792	21	389	418
Clover	1573	566	739	522	—	5940	3441	(g)3516	377	440
(1) Cressy	1118	309	424	356	—	5393	1872	21	233	325
(2) Daisy	1090	465	558	276	(d) 111	2827	1264	21	309	370
Dandelion	1528	475	647	518	—	3686	2461	(h)3256	331	368
Dora	1802	867	888	60	(a) 227	2374	1600	21	314	334
Effie	1541	503	742	718	—	3963	2255	(g)2080	333	352
Eulalie	1890	988	998	40	(a) 222	7863	3146	21	384	399
Fairie	1877	887	907	60	(b) 318	4000	2173	21	312	344
Fanny	1860	789	808	60	(c) 222	3940	2400	21	488	257
Flora	1829	843	863	60	(c) 212	3939	2754	21	438	216
Flox	1603	765	1004	714	—	6521	3226	1111	447	447
Golden Rod	1562	612	842	686	—	6622	2644	470	314	307
Goldie	1842	854	875	60	(c) 201	4759	2980	21	336	377
(3) Helena	208	337	338	—	—	1382	1121	21	291	303
Idarella	1879	884	903	60	(c) 227	5432	2637	21	412	364
Jeannie	1841	990	1010	60	(b) 352	5326	2567	21	414	386
Jersey Lily	1544	359	531	516	—	4995	2742	(h)3616	323	321
Jessaline	1861	856	876	60	(a) 222	5278	3250	21	364	435
Jessie	1871	933	946	36	—	5577	2516	1093	333	376
Julia	1852	859	879	60	(c) 222	4845	2826	21	267	257
Kinkora	1860	717	736	58	(b) 352	4590	2272	21	268	257
Kittie	1532	510	671	482	—	2960	2824	(g-h) 6650	430	253
(4) Lady Le Brocq	1467	357	527	510	—	3483	1097	(h)3034	—	—
(5) Lena	618	168	240	228	—	758	988	(g)2540	—	—
Maizie	1808	777	797	60	(a) 227	4220	2225	21	441	207
Marjory	1861	1118	1138	60	—	5337	2934	1102	378	405
(2) Max Belle	1102	362	483	362	—	4360	1718	21	338	351
(2) Minta Bella	1111	397	518	360	—	4788	1801	21	341	325
Nancy B	1860	888	908	60	(a) 222	6166	3191	21	472	234
(6) Nett	1671	400	575	518	—	6345	1602	(g)4224	467	222
Portelette	1748	881	899	54	(c) 227	6269	3256	21	355	424
Red Top	1884	937	957	60	—	7791	3162	21	332	448
Regina	1577	525	705	536	—	6078	3013	1100	371	434
(7) Rena Myrtle	1345	112	160	144	—	5031	1162	—	—	—
(8) Rhoda	1665	768	787	60	—	4494	1136	—	—	—
Rowena	1646	526	698	518	—	3606	2713	(g-h) 7301	338	369
(3) Salida	217	343	344	—	—	1061	1258	21	293	363

*All the cows were out to rather short pasturage, five and a half months.

1. From Jan. 25. (a) Atlas gluten meal. (b) Cottonseed bran.
2. From Jan. 21. (c) Corn oil cake. (d) Oat meal.
3. From May 25. (e) Includes more or less Kafir corn (from 270 to 350 lbs.), in no case exceeding 11%, and averaging less than 5% of total weights.
4. To July 12. (f) Potatoes unless otherwise stated.
5. To Feb. 14. (g) Beets. (h) Carrots.
6. To Oct. 1. (i) Mostly peas and oats; about 8% clover, 10% vetch and oats. 180 lbs. oats and rape were fed to Acme, Atalanta, Fanny and Flora, and form a part of the weight stated; about 100 lbs. soja bean forage were fed to Flox, Idarella, and Jeannie, and form a part of the weight stated.
7. To May 14.
8. To May 27.

(j) Generally in nearly equal amounts.

While the foregoing herd record is not strictly a piece of scientific work, it ought to prove of much educational value, and should be a stimulus to better dairy farming, to better breeding, weeding and feeding, and to more economical production. The animals whose dairy doings are here recorded are with few exceptions "farmers' cows," bought by a farmer at farmers' prices from farmers' herds within the limits of a single Vermont town, which, while in a good dairy section, could be matched in this respect by scores of other locations within the state. It is entirely practicable for any good judge of cows to get together another such a herd by the expenditure of some time, trouble and a moderate amount of money. Butter-making with such a herd even at present low prices is still profitable.

V. MISCELLANEOUS FODDER CROPS.

The series of experimental plots referred to in the last two reports* were again planted in 1896. The investigation of the adaptability of different fodder plants to the various climates and soils of the state is prescribed both by the Hatch act and by the state law. Accordingly the station from time to time has made field trials of various crops. No startling results have been obtained, but considerable useful information has been accumulated.

The plantings of the past year have included several leguminous crops, various millets, red and white Kafir corn and white mustard. The follow ng table gives the analyses of these crops.

COMPOSITION OF MISCELLANEOUS FODDER CROPS.

Crop.	Original Substance.		Composition of Dry Matter.							
	Water.	Dry matter.	Crude ash.	Crude protein.	Crude fibre.	Nitrogen-free extract.	Ether extract.	Nitrogen.	Phosphoric acid.	Potash.
Legumes.										
Red Clover Rowen	45.90	54.10	7.14	16.44	28.16	45.27	2.99	2.64	0.46	2.20
Mammoth Red Clover Rowen	58.60	41.40	8.73	18.24	24.53	45.42	3.03	2.92	0.51	2.63
Alsike Clover Rowen	67.24	32.76	9.41	20.02	22.39	45.23	2.95	3.20	0.63	3.66
White Clover Rowen	68.15	31.85	9.03	17.24	25.13	46.18	2.42	2.76	0.53	3.12
Flat Pea	72.63	27.37	5.81	20.66	34.46	36.13	2.94	3.30	0.52	1.46
Vetch and Oats	74.90	25.10	9.03	13.26	32.59	42.45	2.67	2.12	0.63	2.58
Green Soja Bean	65.54	34.46	9.27	16.55	23.44	44.28	6.46	2.65	0.65	1.86
Alfalfa	65.56	34.44	7.82	13.28	33.78	42.64	2.48	2.12	0.47	2.12
Millets, etc.										
Panicle Millet	66.14	33.86	6.95	8.07	32.74	49.90	2.34	1.29	0.42	2.27
Cock's-Foot Millet	67.87	32.13	7.75	9.34	32.35	48.43	2.13	1.50	0.37	2.38
" "	76.42	23.58	8.41	9.68	28.67	51.23	2.01	1.55	0.49	3.16
Hungarian	33.58	66.42	7.09	9.44	28.69	52.52	2.26	1.51	0.40	1.65
Panicle-Millet	59.17	40.83	6.74	7.30	28.36	45.74	1.86	1.17	0.40	2.12
White Kafir Corn	70.55	29.45	7.07	10.43	25.27	53.62	3.61	1.67	0.55	1.72
Red " "	73.82	26.18	6.88	9.01	25.56	55.74	2.81	1.44	0.50	1.74
Miscellaneous.										
White Mustard	87.78	12.22	16.17	31.79	10.96	36.14	4.94	5.09	1.08	4.94
Endive	91.52	8.48	20.11	29.86	10.97	33.83	5.23	4.78	1.08	4.87
Swiss Chard	88.60	11.40	17.78	26.13	8.35	44.84	2.90	4.18	0.92	6.86

*Rpts. Vt. Exp. Sta., 8 (1894). p. 168; 9 (1895), p. 194.

LEGUMINOUS CROPS.

CLOVERS. Red (*Trifolium pratense*); Mammoth red (*Trifolium medium*); Crimson (*Trifolium incarnatum*); Alsike (*Trifolium hybridum*); White (*Trifolium repens*).

The red, mammoth red, and alsike clovers made fair growths for two seasons, averaging from a ton and a half to two tons of hay to the acre. The white clover grew less than a ton of hay to the acre each year. Crimson (or scarlet) clover, spring sown, has proved superior to either of the others. Further attempts were made in 1896 to winter it over, sowings being made in several locations at weekly intervals throughout the summer. The various plots went under the snow in good condition, but hardly a plant was living in the spring. It seems quite certain that only under exceptional circumstances can crimson clover be grown from summer or fall sowing in Vermont.

FLAT PEA (*Lathyrus sylvestris*). This perennial plant made a spindling growth in 1894, a luxuriant crop in 1895 and 1896, ($6\frac{3}{4}$ tons of green fodder, 2 tons hay, $\frac{1}{2}$ ton protein per acre in 1895), and was largely killed out by witch grass in 1897. The crop of 1896 was put in the silo. The silage was not relished. The green fodder is eaten with some reluctance. The writer is, on the whole, fairly well impressed with the crop.

SPRING VETCH AND OATS (*Vicia sativa*). This combination has been grown for several years. The past summer's experience has served to confirm the opinion expressed in the last report, which rates it as inferior to peas and oats.

SOJA BEANS (*Soja hispida; Glycine hispida*). This crop has been grown at the station for several years, and continues to give satisfaction. The green and black varieties have proved to be, on the whole, the best annual cultivated leguminous crops which we have tested.

ALFALFA (*Medicagosativa*). Alfalfa was grown extensively throughout the state in a co-operative experiment carried out under station auspices in 1888. It was winter killed in every one of 44 locations. Small patches have been known to grow well in a few places in the state, and it does well on a large scale in southern New York. A trial at this station in 1896 was unsatisfactory. Only a spindling growth was obtained, and the roots winter killed. A repetition of the trial during the current year, at the date of the present writing (September 1897), warrants hope of a better outcome.

MILLETS AND KAFIR CORN.

MILLETS. Japanese or Cock's-foot Millet (*Panicum crus-galli*). Panicle or "Broom Corn" Millet (*Panicum miliaceum*). "Common" Millets (*Setaria italica*, varieties).

The various millets have been tried at the station for several years and have approved themselves to the feeders as well as to those fed. They make good growths and when fed green are eaten closely. When hayed they are

eaten somewhat less readily. The crop is less rich in protein than are most other fodders. Its rapid growth makes it valuable as a "catch crop" in event of the failure of hay or other crop. The last report contains considerable information upon millets.

KAFIR CORNS. (*Andropogon sorghum vulgaris.*) The Kafir corns are non-saccharine sorghums, natives of South Africa, and are largely grown in the semi-arid regions of the west, where, because of their drought-resisting qualities, they are notably superior to corn. There are three varieties of the non-saccharine sorghums usually classed as Kafir corns, the red, the white, and the black-hulled white. The two former were grown at the station in 1896, made a fair growth, (red at rate of 15 tons green fodder, 4¼ tons of dry fodder; white 13 tons green fodder, 4 tons dry fodder to the acre) and formed seed heads, but did not mature seed. The fodder was much liked by the cattle. The analysis of the dry matter is closely like that of corn.

The Kafir corns have not done well at the Ontario,* Massachusetts,† and Michigan‡ stations and their failure to mature seed in the present trial is against them. No comparative trials of corn and Kafir corn fodders have as yet been made. Corn meal has proved superior to Kafir corn meal in several trials made with hogs and steers at the Kansas station.¶ There seems at present to be no good reason for growing Kafir corn in any climate where indian corn can be raised successfully. Further experience may of course modify this conclusion, but it seems to be the part of wisdom for the present to plant Kafir corn in Vermont, if at all, in only a limited way.§

MISCELLANY.

Analyses of three salad plants were made. It will be observed that they are all notably rich in nitrogen, phosphoric acid and potash.

WHITE MUSTARD (*Brassica alba*) is remarkably rich in nitrogen. Many investigators both in this country and in Germany have sought to determine how it thus enriched itself but have not as yet been able to prove that, like the leguminous plants, it can draw upon atmospheric stores of nitrogen. Brooks‖ strongly recommends it as a most advantageous crop for green manuring in the North. He states that "sown in standing corn at the time of last cultivation, it helps to keep down weeds, furnishes useful pasturage for sheep or young stock, conserves soil nitrogen, does not decrease the yield of corn the year it is sown, and can be counted upon to improve the soil if turned under. It also helps largely to prevent soil washing in winter." It is not eaten by cattle to any extent. Even if it were it might well be expected to taint the milk.

*Rpt Ont. Agl. Coll. and Exp. Farm, 17 (1891), p. 105.
†Rpt. Mass. (State) Exp. Sta., 11 (1893), p. 215.
‡Bul. Mich, Exp. Sta. 47 (1889) p. 43.
¶Bul. Kan. Exp. Sta. 53 (1895) pp. 103-107.
§Farmers' Bulletin No. 37, U. S. Dept. Agr. treats of Kafir corn, its characteristics, culture and uses, and is full of information upon the subject.
‖Rpt. Mass. (Hatch) Exp. Sta., 9 (1896), p. 110.

VI. TESTS OF DAIRY APPARATUS.

FARM SEPARATORS.

Much data showing the relative efficiencies of various makes of both farm and power separators have been published in the past by this* as well as by other† stations. It seems like piling Ossa on Pelion to add to the list. The great desire among farmers for information on this subject may serve, however, as an excuse for giving a couple of pages of this report to its consideration.

Several trials of farm separators have been made at the station during the past year, partly in connection with dairy school instruction, and partly in the regular course of dairy work. No attempt has been made to carry out an exhaustive investigation of the relative merits of various machines, but simply to observe the character of their skimming when handled as nearly as might be under the prescribed conditions. The temperatures of separation were more or less variable, but seldom if ever fell below 80° or rose above 90°. The milk averaged 5 per cent. of fat, and was made by a herd which at all times contained cows in varying stages of lactation. The analyses were made by the Babcock centrifugal method with the Ohlsonn double-necked bottles.

Separators.	Speed of crank.	Skimmed at rate per hour (in lbs.)	Per cent. of milk taken as cream.	Per cent. of fat in skim milk.
DeLaval Alpha, Baby No. 2				
Rated capacity 350 lbs. per hour.	42	348	19.0	0.05
	42	342	17.5	0.05
	46	348	15.5	0.04
	46	348	15.5	0.05
	48	348	13.8	0.04
	42	348	17.5	0.05
	47	356	14.0	0.05
DeLaval Alpha, Baby No. 3				
Rated capacity [illegible] lbs. per hour. 675	40	591	18.0	0.04
	45	720	17.2	0.06
DeLaval Alpha, Dairy Turbine No. 3				
Rated capacity [illegible] lbs. per hour. 675	6000‡	686	15.5	0.02
	6070‡	680	14.7	0.04
	5780‡	675	17.0	0.03

*Bul. Vt. Exp. Sta., 27 (1892); Rpts., 5 (1891), pp. 38-44; 6 (1892), pp. 136-143; 7 (1893), pp. 92-100; 8 (1894), pp. 151-160.

†Rpt. Wis. Exp. Sta., 8 (1891), p. 79, Bul. 46 (1895); Buls. Cornell Exp. Sta., 39 (1892); 66 (1894); 105 (1895); Buls. Pa. Exp. Sta., 20 (1892); 22 (1893); 27 (1894); 38 (1897); Rpts. (1892), pp. 51-79; (1894), pp. 13-35; Bul. Del. Exp. Sta., 17 (1892); Rpts. 5 (1892), pp. 110-123; 6 (1893), p. 192: Bul. Iowa Exp. Sta., 25 (1893), pp. 32-38; Bul. N.C. Exp. Sta. 114 (1895); Rpt. Me. Exp. Sta., (1896), pp. 35-36.

‡Revolutions.

Separators.	Speed of crank.	Skimmed at rate per hour (in lbs.)	Per cent. of milk taken as cream.	Per cent. of fat in skim milk.
DeLaval Alpha, Humming Bird	60†	138	17.7	0.05
Rated capacity 150 lbs. per hour.	62†	196	9.4	0.02
Empire No. 5	9000*	468	17.9	0.03
Rated capacity 400 lbs. per hour.	9000*	458	17.0	0.02
Empire No. 7, "Mikado"	53	240	16.7	0.10
Rated capacity 200 lbs. per hour.	—	—	—	0.11
Sharples Safety, Hand	45	300	20.0	0.18
Rated capacity 300 lbs. per hour.	48	300	18.0	0.16
	50	300	16.0	0.12
	50	294	14.3	0.14
	50	300	16.0	0.12
United States No. 5	47	336	24.5	0.03
Rated capacity 350 lbs. per hour.	47	336	18.0	0.04
	47	336	16.0	0.05
	47	342	15.8	0.05
	47	342	14.0	0.05
	47	336	14.3	0.04
	47	342	15.8	0.05
	47	336	14.3	0.05
	50	384	20.8	0.04
United States No. 7, "Midget"	47	216	20.0	0.02
Rated capacity 200 lbs. per hour.	50	237	13.0	0.04
	—	—	—	0.03
United States No. 3	8000*	708	14.5	0.06
Rated capacity 650 lbs. per hour.	50	675	14.6	0.05

*Revolutions.
†Drags.

One of the most frequent questions asked of the station is "what is the best farm separator." Our present feeling in the matter is that there is not, of necessity, any one make that is "best" in all points; that machines of all the more prominent makes are capable of doing a good grade of work when properly handled; that, since good skimming is the rule, other points, such as initial cost, durability, probable repair bills, ease of operation, etc., are now more important; and finally, since flaws may occur in individual machines of any make, that agents' claims and records of other machines of the same make are of less value, touching the quality of skimming than is *the analysis of the skim-milk of the individual machine offered.* Many farmers in this state have bought separators, on the condition that the skim-milks should be submitted to the experiment station for analysis, purchase to follow its favorable, and rejection, its unfavorable report. The buyer thus has, free of expense, the advantage of the advice of disinterested experts, which, moreover, is given in ignorance of the kind of machine under trial.

VII. APPENDIX CONTAINING CONDENSED DATA PERTAINING TO ARTICLES I AND II UNDER "DAIRYING."

I. WEIGHTS OF COWS.

II. AVERAGE BARN TEMPERATURES, WITH RANGES AND PERCENTAGES OF UNIFORMITY.

III. (a) ANALYSES OF FODDERS AND FEEDS; (b) COMPARISON OF ANALYSES AND CALCULATIONS ON DRY BASIS; (c) DIGESTION CO-EFFICIENTS; (d) POUNDS OF DIGESTIBLE INGREDIENTS IN 100 POUNDS OF DRY MATTER IN FODDERS AND FEEDS, ETC.

IV. FEEDING RECORDS OF THE INDIVIDUAL COWS IN PERIOD LENGTH, EQUAL BALANCE, AND EXPERIMENTAL ERROR TESTS.

V. RECORDS SHOWING TOTAL PRODUCTION AND SAME PER UNIT FOR EACH INDIVIDUAL COW IN PERIOD LENGTH, EQUAL BALANCE, AND EXPERIMENTAL ERROR TESTS.

VI. "DIFFERENCE TABLES." (a) PERIOD LENGTH; (b) EQUAL BALANCE; (c) EXPERIMENTAL ERROR.

VII. FEEDING RECORDS OF THE INDIVIDUAL COWS IN FEEDING TESTS UPON SILAGES AND POTATOES.

VIII. RECORDS SHOWING TOTAL PRODUCTION AND SAME PER UNIT FOR EACH INDIVIDUAL COW IN FEEDING TESTS ON SILAGES AND POTATOES.

IX. DIFFERENCE TABLES. (a) SILAGES; (b) SILAGE VS. POTATOES.

I. WEIGHTS OF COWS.

Period number.	Period Length.	Acme.	Dora.	Effie.	Atalanta.	Goldie.	Fanny.	Maizie.	Kitty.	Nancy B.	Marjory.	Minta Bella.
I	Beginning	862	763	843	823	810	868	875	808	895	788	685
I	End	913	788	905	839	873	914	874	853	968	828	683
II		844	802	873	879	908	988	900	900	992	839	736
III		877	811	912	895	910	952	918	919	998	879	698
V		891	832	944	894	Not	taken	...	...	...	...	...
V		912	830	942	...	...	...	...	...	...	...	...
VI		875	851	931	...	...	...	...	...	...	...	...

Period number.	Equal Balance.	Red Top	Max Belle	Bettie	Brownie	Clover	Jeannie	Eulalie	Kinkora	Julia
I	Beginning	839	664	878	789	910	780	1025	727	815
I	End	862	690	933	822	952	805	1084	798	843
II		917	722	982	874	987	862	1178	858	870
III		963	750	970	917	1003	907	1230	868	881
IV		960	777	975	923	Out	of	Ex	perim	ent
V		N	ot tak	en						

I. WEIGHTS OF COWS.—*Continued.*

Period number.	Experimental Error.	Salida	Helena	Daisy	Regina	Rowena	Bess	Golden Rod	Idarella	Besette
I	Beginning	712	618	720	...	825	854	957	900	780
I	End	727	640	743	...	875	900	987	895	740
II		787	662	780	...	930	917	1060	964	822
III		810	690	815	770	960	...	1114	1012	877
IV		839	715	845	832	Out	of	Experiment		
V		862	719	850	845					
VI		Not	taken							

II. AVERAGE BARN TEMPERATURES, WITH RANGES AND PERCENTAGES OF UNIFORMITY.

Period number.	Average temperature.			Range of temperature.			Per cent. of whole within 3° F. of mean.			Average temperature.			Range of temperature.			Per cent. of whole within 3° F. of mean.		
	5 A M	12 M	6 P M	5 A M	12 M	6 P M	5 A M	12 M	6 P M	5 A M	12 M	6 P M	5 A M	12 M	6 P M	5 A M	12 M	6 P M
	4-week period and experimental error.									Equal balance.								
I. Pre	49	48	50	43-66	41-64	43-64	30	20	40	50	48	51	43-66	41-64	43-64	33	50	42
Exp	46	48	49	42-53	41-48	43-59	89	56	83	45	44	48	38-53	41-48	43-58	87	96	87
II. Pre	44	45	48	38-56	42-48	45 51	60	100	100	50	47	49	42-62	42-54	46-59	25	75	100
Exp	47	46	50	40-62	40-56	42-59	56	61	72	46	45	48	38-56	38-52	42-52	44	89	86
III. Pre	48	46	48	40-52	38-50	42-52	70	80	80	48	46	48	42-56	40-50	45-52	58	75	91
Exp	46	47	48	38-56	42-52	40-52	39	78	89	51	48	50	45-58	45-52	36-52	74	78	91
IV. Pre	48	47	49	43-56	45-50	45-52	60	100	90	53	50	50	50-52	48-53	48-52	100	100	100
Exp	49	47	48	42-56	40-52	36-52	78	89	83	54	55	55	46-60	50-60	48-60	72	83	78
V. Pre	53	50	50	50-58	45-52	48-52	90	90	100	61	61	62	52-66	50-68	58-70	60	40	40
Exp	54	53	53	50-60	48-60	48-60	72	72	67	60	63	64	52-71	51-72	57-72	44	39	44
VI. Pre	56	56	57	46-66	50-68	52-68	50	60	60									
Exp	60	62	61	52-66	50-70	54-70	50	44	56									
	6-week period.									7-week period.								
I. Pre	49	47	50	43-66	41-64	43-64	47	59	53	49	47	50	43-66	41-64	43-64	47	59	41
Exp	46	47	50	38-62	41-56	45-59	63	52	70	46	46	50	38-62	40-57	45-59	63	78	72
II. Pre	45	45	49	40-50	40-50	42-56	80	80	80	46	45	47	40-52	38-50	42-52	47	82	82
Exp	47	46	48	38-56	38-52	40-52	56	81	89	47	46	48	38-58	40-56	36-52	48	78	87
III. Pre	48	46	48	42-56	40-50	36-52	67	80	87	50	48	49	45-56	45-52	46-52	76	82	94
Exp	51	49	50	47-58	44-53	45-52	78	78	93	52	53	53	46-60	45-60	47-60	63	75	75
IV. Pre	55	54	54	50-60	48-60	47-60	73	80	67									
Exp	59	60	61	46-66	50-70	52-71	41	33	44									
	8-week period.																	
I. Pre	48	47	50	43-66	41-64	43-64	50	60	55									
Exp	46	45	49	38-62	40-57	42-59	58	83	86									
II. Pre	46	46	49	38-52	38-52	45-52	30	80	90									
Exp	48	47	50	40-56	40-52	36-52	75	89	75									
III. Pre	53	49	50	50-58	45-52	47-60	85	70	85									
Exp	58	60	60	46-71	50-72	52-71	42	23	37									

III. ANALYSES OF FODDERS AND FEEDS, DIGESTION COEFFICIENTS, POUNDS OF DIGESTIBLE INGREDIENTS IN FODDERS AND FEEDS, ETC.

(a) ANALYSES OF FODDERS AND FEEDS.*

Materials and Dates of Sampling.	Original Substance.		Composition of Dry Matter.							
	Water.	Dry matter.	Crude ash.	Crude protein.	Crude fibre.	Nitrogen-free extract.	Ether extract.	Nitrogen.	Phosphoric acid.	Potash.
SILAGE.										
Nov. 30, Dec. 14	77.04	22.96	6.82	7.45	24.40	59.11	2.22	1.20	0.49	1.27
Dec. 28, Jan. 11	75.63	24.37	6.47	7.06	24.36	59.74	2.37	1.13	0.51	1.42
Jan. 18, Feb. 1	77.26	22.74	5.92	7.15	24.85	59.68	2.40	1.14	0.66	1.44
Feb. 16, Mch. 1	76.78	23.22	7.40	8.19	27.45	54.49	2.47	1.31	0.66	1.98
Mch. 15, 30	75.61	24.39	6.79	7.69	25.22	57.84	2.46	1.23	0.56	1.66
Apl. 12, 26, May 10	77.12	22.88	6.69	7.45	24.09	59.14	2.63	1.20	0.60	1.65
CORN FODDER.										
Dec. 7, 14	47.49	52.51	5.98	7.27	27.80	56.95	2.00	1.16	0.44	1.24
Dec. 28, Jan. 11	44.45	55.55	6.01	7.17	27.64	57.26	1.92	1.15	0.41	1.41
Jan. 18, Feb. 1	37.74	62.26	6.01	7.27	28.85	55.75	2.12	1.16	0.41	1.36
Feb. 16, Mch. 1	39.06	60.94	5.97	7.35	27.09	57.36	2.23	1.17	0.50	1.33
Mch. 15, 30	35.11	64.89	6.94	6.88	29.68	54.16	2.34	1.10	0.40	1.50
Apl. 12, 26	24.15	75.85	6.56	6.99	27.87	56.08	2.50	1.13	0.44	1.19
HAY.										
Nov. 30, Dec. 28, Feb. 1	14.53	85.47	7.56	8.90	29.88	51.20	2.46	1.43	0.41	1.78
Feb. 16, Mch. 1	11.57	88.43	7.15	7.84	32.49	50.00	2.52	1.25	0.59	1.96
Mch. 15, 30	12.13	87.87	6.01	6.89	31.76	52.49	2.85	1.11	0.39	1.57
Apl. 12, 26	12.79	87.21	6.14	6.76	30.61	54.14	2.35	1.08	0.40	2.00
BEETS.										
Nov. 30, Dec. 28, Feb. 1	83.45	16.55	19.76	9.58	6.72	63.43	0.51	1.54	0.58	2.40
Feb. 16, Mch. 15, 30	82.85	17.15	17.54	9.92	6.13	65.90	0.51	1.59	0.61	2.66
Apl. 12, 26, May 10	85.25	14.75	14.94	11.29	6.85	66.75	0.67	1.81	0.67	3.15
CARROTS.										
March 1	86.74	13.26	21.76	8.84	9.84	58.62	1.04	1.41	0.53	3.69

*Samples were taken at fortnightly intervals, silage, beets, etc., in quadruplicate, corn fodder in sextuplicate, hay and grains, singles. All samples, 276 in all, were analyzed for dry matter and were combined for complete analyses as indicated in the table. In calculating total dry matter eaten, the analyses of the individual samples were used for the appropriate periods; average analyses were used in calculating digestible ingredients and nutritive ratios.

Materials and Dates of Sampling.	Original Substance.		Composition of Dry Matter.							
	Water.	Dry matter.	Crude ash.	Crude protein.	Crude fiber.	Nitrogen-free extract.	Ether extract.	Nitrogen.	Phosphoric acid.	Potash.
ATLAS GLUTEN MEAL.										
Nov. 30	6.85	93.15	2.26	37.05	10.84	35.15	14.70	5.93	0.66	0.08
Dec. 14, 28	7.31	92.69	2.00	36.11	12.22	37.02	12.65	5.80	0.64	0.09
Jan. 11, 18, Feb. 1	6.85	93.15	1.93	36.67	12.40	36.49	12.51	5.87	0.63	0.09
Feb. 16	7.00	93.00	2.19	33.01	11.15	40.88	12.77	5.28	0.66	0.10
Mch. 1, 15, 30	6.10	93.90	2.19	34.34	12.82	38.13	12.52	5.51	0.60	0.13
Apl. 12, 26, May 10	6.53	93.47	2.11	34.83	12.80	37.53	12.73	5.57	0.60	0.12
CORN MEAL AND WHEAT BRAN (EQUAL PARTS).										
Nov. 30, Dec. 14, 28, Jan. 11, 18	10.34	89.66	4.09	13.92	5.24	71.68	5.07	2.23	1.23	.86
Feb. 1, 16, Mch. 1, 15	9.65	90.35	4.02	15.45	5.56	69.60	5.37	2.48	1.11	1.00
Mch. 30, Apl. 12, 26, May 10	9.89	90.11	3.63	13.88	5.39	72.17	4.93	2.22	1.22	1.00
COTTONSEED, LINSEED, CORN AND BRAN (MIXED FEED NO. 1).										
Nov. 30, Dec. 14, 28, Jan. 11, 18	9.22	90.78	5.32	26.54	7.38	54.13	6.63	4.25	1.16	1.39
Feb. 1, 16, Mch. 1, 15	8.68	91.32	5.30	25.06	7.16	55.76	6.72	4.01	1.16	1.49
Mch. 30, Apl. 12, 26, May 10	8.21	91.79	5.14	25.07	7.18	55.74	6.87	4.01	1.22	1.40
ATLAS GLUTEN MEAL, CORN AND BRAN (MIXED FEED NO. 2).										
Jan. 11, 18, Feb. 1, 16	8.42	91.58	3.48	24.03	9.62	54.38	8.49	3.85	1.14	0.78
Mch. 30, Apl. 12	8.12	91.88	3.59	23.48	9.89	55.29	7.75	3.76	1.16	0.83

(*b*) COMPARISON OF ANALYSES AND CALCULATIONS ON DRY BASIS.

MATERIAL.	Crude ash.	Crude protein.	Crude fiber.	Nitrogen-free extract.	Ether extract.
Mixed feed No. 1. Analysis	5.25	25.56	7.24	55.21	6.74
Calculation	5.58	25.04	7.42	54.73	7.23
Analysis ± Calculation	−0.33	+0.52	−0.18	+0.48	−0.49
Mixed feed No. 2. Analysis	3.53	23.76	9.76	54.83	8.12
Calculation	3.46	24.35	9.37	54.39	8.43
Analysis ± Calculation	+0.07	−0.59	+0.39	+0.44	−0.31
Corn and bran. Analysis	3.91	14.42	5.40	71.15	5.12
Calculation	4.16	14.21	6.30	70.84	4.51
Analysis ± Calculation	−0.25	+0.21	−0.90	+0.31	+0.61

(*c*) DIGESTION COEFFICIENTS OF SEPARATE INGREDIENTS AND MIXED FEEDS.

ROUGH FODDERS.	Dry matter.	Crude protein.	Crude fiber.	Nitrogen-free extract.	Ether extract.
Silage	75	65	77	79	82
Corn fodder	71	65	76	73	70
Hay	58	53	56	61	54
Beets	95	91	100	100	50
Carrots					
FINE FEEDS.					
Atlas gluten meal	80	73	100(?)	84	91
Corn meal	88	60	—	93	92
Wheat bran	61	79	22	69	68
Cottonseed meal	76	88	—	64	93
Linseed meal	79	89	57	78	89
Mixed feed No. 1*	75	84	26	79	86
Mixed feed No. 2†	76	73	67	82	87
Corn and bran‡	74	73	18	84	81

(*d*) POUNDS OF DIGESTIBLE NUTRIENTS IN ONE HUNDRED POUNDS OF DRY MATTER IN FODDERS AND FEEDS.

Fodders and feeds.	Protein.	Crude fiber.	Nitrogen-free extract.	Ether extract	Nutritive ratio.
Silage	4.88	19.30	46.08	1.99	1:14.4
Corn fodder	4.65	21.40	41.07	1.53	1:14.3
Hay	4.03	17.46	31.70	1.38	1:13.0
Beets	9.34	6.40	65.36	0.29	1: 7.8
Carrots					
Atlas gluten meal, first lot	26.72	11.82	30.42	12.09	1: 2.7
Atlas gluten meal, second lot	24.86	12.28	32.62	11.53	1: 3.0
Corn meal and wheat bran‡	10.53	0.97	59.77	4.15	1: 6.8
Mixed feed, No. 1*	21.47	1.88	43.62	5.80	1: 2.8
Mixed feed, No. 2†	17.34	6.54	44.96	7.06	1: 4.0

*6 parts wheat bran, 4 parts corn meal, 3 parts cottonseed meal, 3 parts linseed meal (by weight).

†4 parts Atlas gluten meal, 3 parts wheat bran, 2 parts corn meal (by weight).

‡Equal parts by weight.

IV. FEEDING RECORDS OF THE INDIVIDUAL COWS IN PERIOD LENGTH, EQUAL BALANCE AND EXPERIMENTAL ERROR TESTS.

(Showing pounds of each fodder and feed eaten, during each preliminary and experimental period; the pounds of total dry matter in the ration and of otal dry matter in the experimental fodder eaten during each preliminary and experimental period; and the pounds of each digestible nutrient or group of nutrients eaten each experimental period, together with the nutritive ratio.)

FOUR-WEEK PERIOD TEST. ACME, EFFIE, DORA. Period numbers and dates.	Nature of grain ration.	Pounds eaten of						Pounds of digestible ingredients eaten during period.					
		Hay.	½ corn, ½ bran.	Atlas gluten meal.	Silage.	Total dry matter in entire ration.	Total dry matter in experimental fodder.	Dry matter.	Protein.	Crude fiber.	Nitrogen-free extract.	Ether extract.	Nutritive ratio.
		lbs	lbs	lbs	lbs	lbs	lbs						
I. Pre. Nov. 25-Dec. 5	Atlas	99	19	59	252	219.2	72.2						
Exp. Dec. 5-23		174	32	96	647	409.6	117.5	285.6	39.8	64.4	156.9	16.8	1: 6.6
II. Pre. Dec. 23-Jan. 2	Corn and	93	77	3	176	194.1	71.8						
Exp. Jan. 2-20	bran	178	144		493	400.3	129.0	273.4	25.5	50.8	180.4	9.8	1: 10.0
III. Pre. Jan. 20-30	Atlas	97	26	54	327	228.6	73.7						
Exp. Jan. 30-Feb. 17		165	45	99	591	404.9	132.7	283.5	41.0	61.2	157.2	17.4	1: 6.4
IV. Pre. Feb. 17-27	Corn and	88	80		318	223.9	72.3						
Exp. Feb. 27-Mch. 17	bran	162	144		553	404.7	130.2	278.3	25.9	51.6	14.0	10.0	1: 10.1
V. Pre. March 17-27	Atlas	92	20	60	296	227.4	74.4						
Exp. Mch. 27-Apl. 14		157	36	108	526	399.4	134.0	281.2	40.5	61.5	155.3	17.5	1: 6.4
VI. Pre. April 14-24	Corn and	83	80		263	207.3	72.2						
Exp. Apl. 24-May 12	bran	170	144		541	401.7	129.6	274.1	25.6	51.0	180.9	9.9	1: 10.0
Wolff's standard; 18 days' feeding (900 lbs.)								250.2	40.5	—	209.0	—	1: 5.4
I. Pre. Nov. 25-Dec. 5	Atlas	96	21	38	203	187.0	54.4						
Exp. Dec. 5-23		174	32	62	469	339.4	86.0	231.4	29.4	53.2	129.5	12.3	1: 7.2
II. Pre. Dec. 23-Jan. 2	Corn and	96	59	1	269	200.9	53.8						
Exp. Jan. 2-20	bran	170	108		492	360.9	96.7	245.3	21.9	49.3	158.8	8.4	1: 10.5
III. Pre. Jan. 20-30	Atlas	92	23	37	275	194.0	55.2						
Exp. Jan. 30-Feb. 17		164	36	72	490	348.7	99.5	240.4	32.3	53.7	134.2	13.6	1: 6.9
IV. Pre. Feb. 17-27	Corn and	94	60		280	202.3	54.2						
Exp. Feb. 27-Mch. 17	bran	167	108		498	363.3	97.6	246.6	22.0	49.5	159.8	8.5	1: 10.5
V. Pre. Mch. 17-27	Atlas	92	20	40	275	203.5	55 6						
Exp. Mch. 27-Apl. 14		167	36	72	528	374.9	100.2	259.8	32.4	59.0	147.3	13.8	1: 7.4
VI. Pre. Apl. 14-24	Corn and	96	60		306	210.9	54.2						
Apl. 24-May 12	bran	166	108		534	364.2	97.2	246.8	22.0	49.7	159.7	8.4	1: 10.5
Wolff's standard, 18 days feeding (900 lbs.)								250.2	40.5	—	209.0	—	1: 5.4
I. Pre. Nov. 25-Dec. 5	Corn and	99	58		196	185.9	52.4						
Exp. Dec. 5-23	bran	175	108		455	347.3	96.1	233.6	21.1	46.6	151.3	8.1	1: 10.3
II. Pre. Dec. 23-Jan. 2	Atlas	95	21	39	263	199.8	55.0						
Exp. Jan. 2-20		170	36	72	445	352.2	99.4	242.7	32.4	54.4	135.5	13.6	1: 6.9
III. Pre. Jan. 20-30	Corn and	94	74	3	261	206.8	69.4						
Exp. Jan. 30-Feb. 17	bran	163	144		451	369.8	180.0	252.1	24.2	45.0	167.9	9.3	1: 9.8
IV. Pre. Feb. 17-27	Atlas	91	20	40	256	195.4	55.5						
Exp. Feb. 27-Mch. 17		162	36	72	450	350.0	100.3	241.5	31.2	54.2	136.3	15.3	1: 7.2
V. Pre. Mch. 17-27	Corn and	86	60		247	190.1	54.2						
Exp. Mch. 27-Apl. 14	bran	160	108		473	352.5	97.5	240.0	21.5	47.6	155.9	8.3	1: 10.4
VI. Pre. Apl. 14-24	Atlas	86	20	40	256	191.6	55.5						
Exp. Apl. 24-May 12		160	36	72	481	349.5	99.6	240.8	31.1	54.2	135.8	13.2	1: 7.2
Wolff's standard; 18 days feeding (800 lbs)								221.8	36.0	—	185.6	—	1: 5.4

SIX-WEEK PERIOD TEST. ATALANTA, GOLDIE, FANNY. Period numbers and dates.	Nature of grain ration.	Pounds eaten of				Total dry matter in entire ration.	Total dry matter in experimental fodder.	Pounds of digestible ingredients eaten during periods.					Nutritive ratio.
		Hay.	½ corn, ½ bran.	Atlas gluten meal.	Silage.			Dry matter.	Protein.	Crude fiber.	Nitrogen-free extract.	Ether extract.	
		lbs	lbs	lbs	lbs	lbs	lbs						
I. Pre. Nov. 25-Dec. 10	Atlas	145	30	88	422	337.3	109.1						
Exp. Dec. 10-Jan. 6		266	50	150	1000	641.5	183.7	448.5	62.2	101.0	246.9	26.4	1: 6.7
II. Pre. Jan. 6-21	Corn and	144	117	3	560	366.4	107.6						
Exp. Jan. 21-Feb. 17	bran	255	216		1065	648.9	195.0	447.2	40.8	84.6	294.0	15.8	1:10.2
III. Pre. Feb. 17--Mch. 4	Atlas	143	30	90	547	368.0	111.9						
Exp. Mch. 4--31		254	54	162	962	658.3	200.7	462.9	63.3	103.1	257.5	27.3	1: 6.8
IV. Pre. Mch. 31--Apl. 15	Corn and	145	120		519	360.9	108.3						
Exp. Apl. 15--May 12	bran	244	216		1073	650.3	194.3	448.6	40.9	85.9	294.7	15.8	1:10.3
Wolff's standard; 27 days' feeding (900 lbs.)								375.3	60.8	—	313.5	—	1: 5.4
I. Pre. Nov. 25-Dec. 10	Atlas.	141	29	89	382	324.2	109.1						
Exp. Dec. 10-Jan. 6		266	50	150	1079	659.5	183.7	462.0	63.1	104.5	255.2	25.7	1: 6.7
II. Pre. Jan. 6-21	Corn and	147	117	3	620	383.6	107.6						
Exp. Jan. 21-Feb. 17	bran.	247	216		1094	648.4	195.0	448.0	40.8	84.6	294.8	15.8	1:10.3
III. Pre. Feb. 17-Mch. 4	Atlas.	132	30	90	512	350.0	111.9						
Exp. Mch. 4-31		257	54	162	919	649.9	200.7	456.2	63.0	101.5	253.3	27.1	1: 6.7
IV. Pre. Mch. 31-Apl. 15	Corn and	140	120		498	351.5	108.3						
Exp. Apl. 15-May 12	bran.	249	216		896	615.7	194.3	421.8	39.1	79.1	278.2	15.1	1:10.1
Wolff's standard; 27 days' feeding (900 lbs.)								375.3	60.8	—	313.5	—	1: 5.4
I. Pre. Nov. 25-Dec. 10	Corn and	148	118		363	323.1	106.5						
Exp. Dec. 10-Jan. 6	bran.	264	216		904	627.3	193.1	439.7	39.6	81.5	282.7	15.3	1:10.2
II. Pre. Jan. 6-21	Atlas.	143	33	87	559	368.3	110.7						
Exp. Jan. 21-Feb. 17		258	64	152	1068	656.5	199.3	460.9	64.3	101.2	256.2	27.3	1: 6.6
III. Pre. Feb. 17-Mch. 4	Corn and	138	120	3	611	378.7	111.5						
Exp. Mch. 4-31	bran.	247	216		1031	663.3	195.0	458.7	41.5	87.5	301.2	16.1	1:10.3
IV. Pre. Mch. 31-Apl. 15	Atlas.	135	30	90	541	360.9	111.5						
Exp. Apl. 15-May. 12		235	54	162	938	617.9	199.8	434.7	61.3	95.9	240.7	26.5	1: 6.6
Wolff's standard; 27 days' feeding (950 lbs.)								395.0	64.0	—	330.8	—	1: 5.4

SEVEN AND EIGHT-WEEK PERIOD TEST. MAIZIE, KITTIE, NANCY B., MARJORY, MINTA BELLA. Period numbers and dates.	Nature of grain ration.	Pounds eaten of				Total dry matter in entire ration.	Total dry matter in experimental fodder.	Pounds of digestible ingredients eaten during period.					Nutritive ratio.
		Hay.	½ Corn, ½ Bran.	Atlas gluten meal	Silage.			Dry matter.	Protein.	Crude fiber.	Nitrogen-free extract	Ether extract.	
		lbs	lbs	lbs	lbs	lbs	lbs						
I. Pre. Nov. 25-Dec. 12	Corn and	165	134		434	369.5	121.0						
Exp. Dec. 12-Jan. 13	bran.	315	256		1109	762 0	229.1	522.8	47.8	100.1	343.3	18.5	1:10.2
II. Pre. Jan. 13-30	Atlas.	162	40	96	584	402.4	125.3						
Exp. Jan. 30-Mch. 3		301	74	182	1081	742.3	236.8	520.2	73.3	113.9	289.0	31.3	1: 6.6
III. Pre. Mch. 3-20	Corn and	156	136		558	393.7	122.8						
Exp. Mch. 20-Apr. 21	bran.	298	256		1149	764.8	231.0	528.6	48.2	100.7	348.0	18.7	1:10.3
Wolff's standard; 32 days' feeding (900 lbs.)								444.8	72.0	—	371.5	—	1: 5.4
I. Pre. Nov. 25-Dec. 12	Atlas.	162	45	64	409	340.1	100.2						
Exp. Dec. 12-Jan. 13		289	64	192	893	695.2	235.6	487.2	74.0	105.7	264.3	31.6	1:6.1
II. Pre. Jan. 13-30	Corn and	159	127	9	503	378.8	122.1						
Exp. Jan. 30-Mch. 3	bran.	289	256		924	690.9	231.3	473.4	44.7	86.3	314.0	17.2	1:9.9
III. Pre. Mch. 3-20	Atlas.	158	33	102	477	370.0	125.5						
Exp. Mch. 20-Apl. 21		280	64	192	860	692.0	237.8	486.3	71.0	105.9	267.7	30.7	1:6.3
Wolff's standard; 32 days' feeding (900 lbs.)								444.8	72.0	—	371.5	—	1: 5.4
I. Pre. Nov. 25-Dec. 15	Atlas.	197	35	107	622	445.1	130.8						
Exp. Dec. 15-Jan. 20		340	72	216	1757	983.1	263.2	696.6	92.5	157.6	388.4	39.2	1: 7.0
II. Pre. Jan. 20-Feb. 9	Corn and	182	154	6	977	505.2	144.0						
Exp. Feb. 9-Mch. 17	bran.	330	288		1597	926.3	260.2	642.7	57.4	125.7	420.6	22.3	1:10.5
III. Pre. Mch. 17-Apr. 6	Atlas.	193	40	120	821	521.8	148.6						
Exp. Apr. 6 May 12		319	72	216	1399	868.3	266.7	612.9	84.0	136.4	34 .3	36.2	1: 6.8
Wolff's standard; 36 days' feeding (1000 lbs.)								554.4	90.0	—	464.4	—	1: 5.4
I. Pre. Nov. 25-Dec. 15	Atlas.	194	35	107	548	425.5	130.8						
Exp. Dec. 15-Jan. 20		342	72	216	1179	844.5	263.2	592.4	85.7	130.9	324.3	36.5	1: 6.4
II. Pre. Jan. 20-Feb. 9	Corn and	185	154	6	687	445.3	144.0						
Exp. Feb. 9-Mch. 17	bran.	318	288		1150	810.7	260.2	557.8	51.9	103.6	368.8	20.0	1:10.1
III. Pre. Mch. 17-Apr. 6	Atlas.	175	40	120	587	443.0	148.6						
Exp. Apr. 6-May 12		313	72	216	1009	773.8	266.7	542.9	79.4	118.2	298.5	34.4	1: 6.3
Wolff's standard; 36 days' feeding (850 lbs.)								471.2	76.5	—	394.7	—	1: 5.4
I. Pre. Nov. 25-Dec. 15	Corn and	195	158		556	439.2	141.8						
Exp. Dec. 15-Jan. 20	bran.	338	288		1326	871.5	258.1	601.4	54.6	115.5	394.9	21.1	1:10.3
II. Pre. Jan. 20-Feb. 9	Atlas.	179	55	105	716	449.7	147.1						
Exp. Feb. 9-Mch. 17		326	72	216	1043	799.7	267.3	560.3	80.7	122.9	308.8	34.9	1: 6.4
III. Pre. Mch. 17-Apr. 6	Corn and	187	160		559	447.5	144.4						
Exp. Apr. 6-May 12	bran.	326	288		973	769.7	259.4	525.8	49.8	95.7	348.8	19.2	1: 9.9
Wolff's standard; 36 days' feeding (700 lbs.)								388.0	63.0	—	325.0	—	1: 5.4

EQUAL BALANCE TEST. RED TOP, BROWNIE, MAX BELLE, BETTIE. Period numbers and dates.	Nature of grain ration.	Pounds eaten of				Total dry matter in entire ration.	Total dry matter in experimental fodder.	Pounds of digestible ingredients eaten during period.					Nutritive ratio.
		Hay.	Mixed feed No. 1.	Mixed feed No. 2.	Silage.			Dry matter.	Protein.	Crude fiber.	Nitrogen-free extract.	Ether extract.	
		lbs	lbs	lbs	lbs	lbs	lbs						
I. Pre. Nov. 25-Dec. 7	Cot.-Lin.	119	94		326	268.2	85.8						
Exp. Dec. 7-30		230	184		1012	596.5	167.1	413.5	55.1	82.4	242.2	17.0	1:6.7
II. Pre. Dec. 30-Jan. 11	Atlas.	119		108	649	359.8	98.9						
Exp. Jan. 11-Feb. 17		352		333	1894	1048.3	305.0	737.5	86.6	157.8	435.9	34.5	1:7.9
III. Pre. Feb. 17-Mch. 1	Cot.-Lin.	112	96		554	315.1	87.6						
Exp. Mch. 1-24		217	184		1085	618.2	167.8	431.4	56.4	86.6	253.7	17.5	1:6.8
IV. Pre. Mch. 24-Apr. 3	Atlas.	93		90	467	280.2	82.7						
Exp. Apr. 3-21		164		162	818	488.8	148.8	344.3	41.2	72.8	203.5	16.4	1:7.7
V. Pre. Apr. 21-May 1	Cot.-Lin.	94	80		469	265.9	73.2						
Exp. May 1-19		130	146		790	415.5	132.6	291.6	41.3	54.9	171.3	12.6	1:6.3
Wolff's standard; 18 days' feeding (950 lbs.)								263.3	42.8	—	220.6	—	1:5.4
I. Pre. Nov. 25-Dec. 7	Cot.-Lin.	120	94		283	258.6	85.8						
Exp. Dec. 7-30		227	184		874	562.5	167.1	388.5	53.5	75.9	226.9	16.4	1:6.4
II. Pre. Dec. 30-Jan. 11	Atlas.	114		108	472	312.4	98.9						
Exp. Jan. 11-Feb. 17		355		333	1314	916.5	305.0	638.2	80.1	132.3	374.8	31.8	1:7.3
III. Pre. Feb. 17-Mch. 1	Cot.-Lin.	115	96		437	290.8	87.6						
Exp. Mch. 1-24		212	184		794	543.9	167.8	376.5	52.8	72.3	220.0	16.1	1:6.3
IV. Pre. Mch. 24-Apr. 3	Atlas.	92		90	334	246 4	82.7						
Exp. Apr. 3-21		166		162	535	421.2	148.8	293.3	37.9	59.7	172.1	15.1	1:7.1
Wolff's standard; 18 days' feeding (900 lbs.)								249.5	40.5	—	209.0	—	1:5.4
I. Pre. Nov. 25-Dec. 7	Cot.-Lin.	107	91		220	229.4	83.1						
Exp. Dec. 7-30		222	184		533	480.5	167.1	327.7	49.5	60.1	189.7	14.8	1:5.8
II. Pre. Dec. 30-Jan. 11	Atlas.	105		108	290	260.4	98.9						
Exp. Jan. 11-Feb. 17		323		333	840	778.9	305.0	539.7	73.6	106.3	315.3	29.3	1:6.7
III. Pre. Feb. 17-Mch. 1	Cot.-Lin.	106	96		271	244.2	87.6						
Exp. Mch. 1-24		205	184		532	474.7	167.8	325.5	49.5	59.1	189.0	14.8	1:5.8
IV. Pre. Mch. 24-Apr. 3	Atlas.	88		90	240	219.5	82.7						
Exp. Apr. 3-21		152		162	456	389.9	148.8	271.9	36.4	53.8	159 4	14.2	1:6.8
V. Pre. Apr. 21-May 1	Cot.-Lin.	85	80		254	208.0	73.2						
Exp. May. 1-19		126	144		466	342.2	130.8	237.3	37.4	41.2	138.1	11.4	1:5.6
Wolff's standard; 18 days' feeding (750 lbs.)								207.9	33.8	—	174.2	—	1:5.4
I. Pre. Nov. 25-Dec. 7	Cot.-Lin.	118	94		303	261.8	85.8						
Exp. Dec. 7-30		224	184		857	556.4	167.1	384.4	53.2	74.7	224.4	16.3	1:6.4
II. Pre. Dec. 30-Jan. 11	Atlas.	109		108	422	295.9	98.9						
Exp. Jan. 11-Feb. 17		330		333	1063	836.6	305.0	582.0	76.4	117.3	341.1	30.4	1:7.0
III. Pre. Feb. 17-Mch. 1	Cot.-Lin.	112	96		336	264.6	87.6						
Exp. Mch. 1-24		208	184		623	499.3	167.8	343.6	50.7	63.8	200.0	15.2	1:6.0
IV. Pre. Mch. 24-Apr. 3	Atlas.	88		90	261	224.8	82.7						
Exp. Apr. 3-21		163		162	489	407.3	148.8	283.4	37.2	57.0	160.1	14.8	1:7.0
V. Pre. Apr. 21-May 1	Cot.-Lin.	95	80		283	223.7	73.2						
Exp. May 1-19		130	144		472	347.1	130.8	240.4	37.6	42.1	139.9	11.2	1:5.6
Wolff's standard; 18 days' feeding (950 lbs.)								263.3	42.8	—	220.6	—	1:5.4

EQUAL BALANCE TEST.	Nature of grain ration.	Pounds eaten of				Total dry matter in entire ration.	Total dry matter in experimental fodder.	Pounds of digestible ingredients eaten during period.					Nutritive ratio.
CLOVER, JEANNIE, EULALIE, KINKORA, JULIA.		Hay.	Mixed feed No. 1.	Corn fodder.	Beets.			Dry matter.	Protein.	Crude fiber.	Nitrogen-free extract.	Ether extract.	
Period numbers and dates.		lbs	lbs	lbs	lbs	lbs	lbs						
I. Pre. Nov. 25-Dec. 7	Cot.-Lin.	118	94		321	266.1	85.8						
Exp. Dec. 7-30		224	184		916	569.4	167.1	394.1	53.9	77.2	230.4	16.5	1 : 6.5
II. Pre. Dec. 30-Jan. 11	Atlas.	110		108	491	313.7	98.9						
Exp. Jan. 11-Feb. 17		344		333	1512	952 8	305.0	667.1	82.0	139.5	392.9	32.6	1 : 7.5
III Pre. Feb. 17-Mch. 1	Cot.-Lin.	106	96		467	289.7	87.6						
Exp. Mch. 1-24		202	184		816	540.4	167.8	375.3	52.7	71.8	219.7	16.1	1 : 6.3
Wolff's standard; 23 days' feeding (1000 lbs.)								354.2	57.5	—	296.7	—	1 : 5.4
I. Pre. Nov. 25-Dec. 7	Cot.-Lin.	118	94		273	254.5	85.8						
Exp. Dec. 7-30		225	184		731	528.2	167.1	363.0	51.9	69.3	211.3	15.7	1 : 6.2
II. Pre. Dec. 30-Jan. 11	Atlas.	112		108	366	284.9	98.9						
Exp. Jan. 11-Feb. 17		346		333	1080	854.3	305.0	592.9	77.8	120.5	347.2	30.6	1 : 7.1
III. Pre. Feb. 17-Mch. 1	Cot.-Lin.	110	96		349	265.9	87.6						
Exp. Mch. 1-24		213	184		676	516.4	167.8	355.7	51.5	67.0	207.2	15.5	1 : 6.1
Wolff's standard; 23 days' feeding (850 lbs.)								301.1	48.9	—	252.2	—	1 : 5.4
I. Pre. Nov. 25-Dec. 7	Cot.-Lin.	119	94		326	268.2	85.8						
Exp. Dec. 7-30		229	184		1078	610.7	167.1	424.4	55.9	85.1	248.8	17.3	1 : 6.8
II. Pre. Dec. 30-Jan. 11	Atlas.	114		108	607	345.3	98.9						
Exp. Jan. 11-Feb. 17		330		333	1734	992.1	305.0	698.6	84.0	147.3	412.7	33.5	1 : 7.7
III. Pre. Feb. 17-Mch. 1	Cot.-Lin.	103	96		516	298.5	87.6						
Exp. Mch. 1-24		213	184		439	579.6	167.8	403.1	54.6	79.2	236.4	16.8	1 : 6.6
Wolff's standard; 23 days' feeding (1050 lbs.)								371.9	60.4	—	311.5	—	1 : 5.4
I. Pre. Nov. 25-Dec. 7	Cot.-Lin.	113	94		227	239.0	85.8						
Exp. Dec. 7-30		225	184		546	486.0	167.1	331.5	49.8	61.1	191.9	14.8	1 : 5.8
II. Pre. Dec. 30-Jan. 11	Atlas.	112		108	298	268.3	98.9						
Exp. Jan. 11-Feb. 17		331		333	860	790.4	305.0	547.2	74.2	108.4	319.7	29.4	1 : 6.8
III. Pre. Feb. 17-Mch. 1	Cot.-Lin.	107	96		274	245.8	87.6						
Exp. Mch. 1-24		194	184		499	457.2	167.8	314.0	48.7	55.9	182.4	14.5	1 : 5.6
Wolff's standard; 23 days' feeding (850 lbs.)								301.1	57.5		296.7		1 : 5.4
I. Pre. Nov. 25-Dec. 7	Cot.-Lin.	118	94		300	261.0	85.8						
Exp. Dec. 7-30.		225	184		742	530.7	167.1	364.9	52.0	69.7	212.5	15.7	1 : 6.3
II. Pre. Dec. 30-Jan. 11	Atlas.	112		108	370	285.9	98.9						
Exp. Jan. 11-Feb. 17		337		333	1011	830.6	305.0	576.4	76.1	116.0	337.4	30.2	1 : 7.0
III Pre. Feb. 17-Mch. 1	Cot.-Lin.	109	96		329	260.4	87.6						
Exp. Mch. 1-24		202	184		608	490.4	167.8	337.8	50.3	62.1	196.7	15.1	1 : 5.9
Wolff's standard; 23 days' feeding (850 lbs.)								301.1	57.5	—	296.7	—	1 : 5.4

EXPERIMENTAL ERROR TEST. SALIDA, DAISY, HELENA. Period numbers and dates	Nature of grain ration.	Pounds eaten of				Total dry matter in entire ration.	Total dry matter in experimental fodder.	Pounds of digestible ingredients eaten during period.					Nutritive ratio.
		Hay.	Mixed feed No. 1.	Corn fodder.	Beets.			Dry matter.	Protein.	Crude fiber.	Nitrogen-free extract.	Ether extract.	
		lbs	lbs	lbs	lbs	lbs	lbs						
I. Pre. Nov. 25-Dec. 5		117	59	52	60	194.3	27.5						
Exp. Dec. 5-23		100	108	255	108	337.6	132.7	237.1	32.6	46.7	137.9	8.8	1:5.9
II. Pre. Dec. 23-Jan. 2		53	60	130	60	182.6	73.2						
Exp. Jan. 2-20		94	108	237	108	337.8	143.6	237.6	32.5	47.6	137.9	9.0	1:6.0
III. Pre. Jan. 20-30		50	60	128	60	185.5	79.7						
Exp. Jan. 30-Feb. 17		92	108	236	108	333.0	137.1	234.2	32.4	46.2	135.9	9.0	1:5.9
IV. Pre. Feb. 17-27		48	60	121	30-45	181.8	73.7						
Exp. Feb. 27-Mch. 17		90	108	209	162	340.9	138.1	242.0	33.1	46.8	141.4	9.0	1:6.0
V. Pre. Mch. 17-27		47	60	104	90	179.8	67.5						
Exp. Mch. 27-Apl. 14		82	108	198	162	334.3	138.6	238.2	33.1	45.5	139.2	9.0	1:5.9
VI. Pre. Apl. 14-24		44	60	94	90	177.7	71.3						
Exp. Apl. 24-May 12		76	108	168	162	302.3	111.5	215.6	31.3	39.2	126.2	8.5	1:5.5
Wolff's standard; 18 days' feeding (800 lbs.)								221.8	36.0	—	185.6	—	1:5.4
I. Pre. Nov. 25-Dec. 5		115	59	52	60	192.6	27.5						
Exp. Dec. 5-23		96	108	236	108	324.3	122.9	228.1	32.0	44.0	132.7	8.8	1:5.8
II. Pre. Dec. 23-Jan. 2		52	60	106	60	168.2	59.7						
Exp. Jan. 2-20		92	108	192	108	308 3	115.8	216.8	31.1	41.3	125.9	8.6	1:5.7
III. Pre. Jan. 20-30		50	60	119	60	179.9	74.1						
Exp. Jan. 30-Feb. 17		91	108	200	108	311.3	116.2	218.9	31.4	41.6	127.1	8.6	1:5.6
IV. Pre. Feb. 17-27		50	60	108	30-45	175.7	65.8						
Exp. Feb. 27-Mch. 17		89	108	176	162	318.2	116.3	226.0	32.1	42.0	132.2	8.6	1:5.7
V. Pre. Mch. 17-27		45	60	77	90	160.5	50.0						
Exp. Mch. 27-Apl. 14		82	108	142	162	295.1	99.4	210.4	31.2	37.1	123.1	8.4	1:5.4
VI. Pre. Apl. 14-24		38	60	50	90	139.0	37.9						
Exp. Apl. 24-May 12		79	108	91	162	253.9	60.4	180.8	29.1	28.7	106.0	7.7	1:4.9
Wolff's standard; 18 days' feeding (800 lbs.)								221.8	36.0	—	185.6	—	1:5.4
I. Pre. Nov. 25-Dec. 5		116	59	54	60	194.5	28.6						
Exp. Dec. 5-23		101	108	252	108	337.0	131.2	236.6	32.6	46.5	137.5	9.0	1 : 5.9
II. Pre. Dec. 23-Jan. 2		55	60	126	60	182.0	70.9						
Exp. Jan. 2-20		99	108	225	108	334.2	135.8	234.4	32.3	46.6	136.0	9.0	1 : 5.9
III. Pre. Jan. 20-30		54	60	128	60	188.8	79.7						
Exp. Jan. 30-Feb. 17		100	108	227	108	334.7	131.9	234.5	32.5	46.3	136.0	9.0	1 : 5.9
IV. Pre. Feb. 17-27		52	60	117	30-45	183.0	71.3						
Exp. Feb. 27-Mch. 17		96	108	205	162	343.5	135.5	243.1	33.2	47.1	142.0	9.0	1 : 6.0
V. Pre. Mch. 17-27		45	60	85	90	165.7	55.2						
Exp. Mch. 27-Apl. 14		88	108	159	162	312.2	111 3	221.8	32.0	40.6	129.7	8.6	1 : 5.6
VI. Pre. Apl. 14-24		46	60	66	90	158.2	50.1						
Exp. Apl. 24-May 12		87	108	141	162	294.3	93.6	208.6	30.9	37.1	122.0	8.3	1 : 5.4
Wolff's standard; 18 days' feeding (700 lbs.)								194.0	31.5	—	162.5	—	1 : 5.4

EXPERIMENTAL ERROR TEST. REGINA, ROWENA, BESS, GOLDEN ROD IDARELLA, BESSETTE. Period numbers and dates.	Nature of grain ration.	Pounds eaten of				Total dry matter in entire ration.	Total dry matter in experimental fodder.	Pounds of digestible ingredients eaten during period.					Nutritive ratio.
		Hay.	Mixed feed No. 1.	Corn fodder.	Beets.			Dry matter.	Protein.	Crude fibre.	Nitrogen-free extract.	Ether extract.	
		lbs	lbs	lbs	lbs	lbs	lbs						
III. Pre. Jan. 20-30		72	48	99	60	174.7	61.6						
Exp. Jan. 30-Feb. 17		133	144	184	108	371.2	106.9	258.1	39.5	46.6	149.2	10.9	1 : 5.2
IV. Pre. Feb. 17-27		79	80	117	30-45	225.2	71.3						
Exp. Feb.27-Mch. 17		130	144	180	162	389.4	118.9	273.1	40.7	49.3	158.9	11.1	1 : 5.4
V. Pre. Mch. 17-27		70	80	92	90	210.7	59.						
Exp. Mch. 27-Apl. 14		126	144	160	162	379.1	112.0	266.3	40.5	47.1	154.9	11.0	1 : 5.3
VI. Pre. Apl. 14-24		61	80	66	90	189.6	50.1						
Exp. Apl. 24-May 12		119	144	151	162	362.5	100.2	254.6	39.4	44.1	148.1	10.7	1 : 5.2
Wolff's standard; 18 days' feeding (800 lbs.)								221.8	36.0	—	185.6	—	1 : 5.4
I. Pre. Nov. 25-Dec. 5		142	78	76	60	224.3	18.4						
Exp. Dec. 5-23		178	144	581	108	431.9	126.4	301.5	42.3	55.2	177.4	12.3	1 : 5.8
II. Pre. Dec. 23-Jan. 2		96	70	342	60	246.3	81.5						
Exp. Jan. 2-20		172	144	629	108	446.6	153.7	313.6	42.9	58.6	184.9	12.7	1 : 6.0
III. Pre. Jan. 20-30		93	80	350	60	239.4	79.6						
Exp. Jan. 30-Feb. 17		157	144	587	108	413.8	128.8	290 8	41.7	52.2	171.2	12.1	1 : 5.6
Wolff's standard; 18 days feeding (950 lbs.)								263.3	42.8	—	220.6	—	1 : 5.4
I. Pre. Nov. 25-Dec. 5		142	78	92	60	228.1	22 2						
Exp. Dec. 5-23		180	144	639	108	446.2	139.0	312.0	43.0	57.9	183.7	12.6	1 : 5.9
II. Pre. Dec. 23-Jan. 2		94	80	394	60	256.9	93.8						
Exp. Jan. 2-20		160	144	660	108	444.0	161.3	313.4	42.9	58.3	185.2	12.7	1 : 6.0
III. Pre. Jan. 20-30		90	80	378	60	243.2	85.9						
Exp. Jan 30-Feb. 17		160	144	670	108	434.5	146.9	305.9	42.7	56.1	180.3	12.5	1 : 5.8
Wolff's standard; 18 days' feeding (900 lbs.)								250.2	40.5	—	209.0	—	1 : 5.4
I. Pre. Nov. 25-Dec. 5		131	78	62	60	229.1	32.8						
Exp. Dec. 5-23		134	144	288	108	416.1	148.9	290.2	41.5	56.0	168.2	11.5	1 : 5.7
II. Pre. Dec. 23-Jan. 2		71	80	140	60	220.0	78.8						
Exp. Jan. 2-20		130	144	240	108	402.1	144.8	280.5	40.7	53.7	162,3	11.4	1 : 5.6
III. Pre. Jan. 20-30		72	80	131	60	223.8	81 5						
Exp. Jan. 30-Feb. 17		127	144	236	108	396.2	137.1	276.5	40.7	52.1	159.9	11.3	1 : 5.5
Wolff's standard; 18 days' feeding (1050 lbs.)								291.1	47.3	—	243.8	—	1 : 5.
I. Pre. Nov. 25-Dec. 5		137	78	56	60	231.2	29.7						
Exp. Dec. 5-23		130	144	233	108	385.0	121.3	268.6	40.1	49.4	155.7	11.1	1 : 5.4
II. Pre. Dec. 23-Jan. 2		56	80	67	60	167.9	37.7						
Exp. Jan. 2-20		118	144	140	108	331.6	84.5	231.7	37.5	39.1	134.3	10 3	1 : 4.9
III. Pre. Jan. 20-30		70	86	86	60	194.2	53.5						
Exp. Jan. 30-Feb. 17		123	144	161	108	349.1	93.5	243.6	38.6	42.2	140.9	10.6	1 : 5.0
Wolff's standard; 18 days' feeding (950 lbs.)								263.3	42.8	—	220.6	—	1 : 5.4
I. Pre. Nov. 25 Dec. 5		130	78	49	60	221.4	26.0						
Exp. Dec. 5-23		134	144	254	108	399.4	132.2	278.4	40.8	52.4	161.3	11.3	1 : 5.5
II. Pre. Dec. 33-Jan. 2		69	80	127	60	212,9	71.5						
Exp. Jan. 2-20		127	144	228	108	392.4	137.6	273.9	40.3	51.8	158.5	11.2	1 : 5.5
III. Pre. Jan. 20-3 0		70	80	133	60	223.5	82.8						
Exp. Jan. 30. Feb. 17		131	144	246	108	405.4	142.9	282.7	41.1	54.0	163.4	11.4	1 : 5.6
Wolff's standard; 18 days' feeding (850 lbs.)								236.0	38.3	—	197.3	—	1 : 5.4

V. RECORD OF THE INDIVIDUAL COWS IN PERIOD LENGTH, EQUAL BALANCE AND EXPERIMENTAL ERROR TESTS.

(Showing pounds of total dry matter in ration and dry matter in experimental fodder eaten; the pounds of milk given; per cent. of total solids and of fat; pounds of same; and pounds of milk, total solids, and fat given per 100 pounds total dry matter, and per 100 pounds dry matter in experimental fodder eaten; all for each preliminary and each experimental ration for cows in "period length" test, and for each experimental period for cows in other tests).

Name of cow.	Period Number.	4-WEEK PERIODS.	Experimental Fodder.	Dry Matter Eaten.*	Dry Matter Eaten.†	Milk.	Total Solids.	Fat.	Total Solids.	Fat.	WEIGHT OF PRODUCTS OBTAINED PER 100 LBS. OF DRY MATTER EATEN. IN ENTIRE RATION. Milk.	Total Solids.	Fat.	IN EXPERIMENTAL FODDER. Milk.	Total Solids.	Fat.
				lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	s	lbs
ACME.	I.	Pre. Nov. 25-Dec. 5	Atlas.	219.2	72.2	276.1	12.22	3 86	33.74	10.66	125.9	15.4	4.9	382.4	46.7	14.8
		Exp. Dec. 5-23		409.6	117.5	561.8	12 40	3.90	69.66	21.92	137.2	17.0	5.4	478.1	59.3	18.7
	II.	Pre. Dec. 23-Jan. 2	Corn-	194.1	71.8	242.0	12.54	3.86	30.35	9.33	124.7	15.6	4.8	337.1	42.3	13.0
		Exp. Jan. 2-20	bran.	400.3	129.0	434 8	12.77	3.94	55 52	17.13	108.6	13.9	4.3	337.1	43.0	13.3
	III.	Pre. Jan. 20-30	Atlas.	228.6	73.7	255.3	12 52	3.98	31.95	10.16	111.7	14.0	4.4	346.4	43.4	13.8
		Exp. Jan. 30-Feb. 17		404 9	132.7	462.1	12.59	4.00	58.19	18.46	114.1	14.4	4.6	348.2	43.9	13.9
	IV.	Pre. Feb. 17-27	Corn-	223.9	72.3	219.9	12.78	3.96	28.11	8.71	98.2	12.6	3.9	304.2	38 9	12.0
		Exp. Feb. 27-Mch. 17	bran.	404.7	130 2	358.3	12.95	4.08	46.40	14.60	88.5	11.5	3.6	275.2	35.6	11.2
	V.	Pre Mch. 17-27	Atlas.	227.4	74.4	224.8	12.71	4.16	28.56	9.35	98.9	12.6	4.1	302.2	38.4	12.6
		Exp. Mch. 27-Apl. 14		399.4	134.0	396.7	12.78	4.24	50.68	16.80	99.3	12.7	4.2	296.1	37.8	12.5
	VI.	Pre. Apl. 14-24	Corn-	203.3	72·2	203.3	12 64	3 97	25.70	8.08	98.1	12.4	3.9	281.6	35.6	11.2
		Exp. Apl. 24-May 12	bran.	401.7	129.6	379.1	12.46	3.74	47.24	14 17	94.4	11.8	3.5	292.5	36.5	10.9
DORA.	I.	Pre. Nov. 25-Dec. 5	Corn-	185.9	52.4	160.0	14.97	5.29	23.95	8.46	86.1	12.9	4.6	305.4	45.7	16.1
		Exp. Dec. 5-23.	bran.	347.3	96.1	294.6	15.04	5.25	44.31	15.46	84.8	12.8	4.5	306.6	46.1	16.1
	II.	Pre. Dec. 23-Jan. 2	Atlas.	199.8	55.0	173.4	15.30	5.77	26.53	10.00	86.8	13.3	5.0	315.3	48.2	18.2
		Exp. Jan. 2-20		352.2	99.4	314.7	15.11	5.57	47.54	17.54	89.4	13.5	5.0	316.6	47.8	17.6
	III.	Pre. Jan. 20-30	Corn-	206.8	69.4	159.4	14 99	5.24	23.89	8.36	77 1	11.6	4.0	229.7	34.4	12.0
		Exp. Jan. 30-Feb. 17	bran.	369.8	130.0	265 2	15.06	5.32	39.93	14.11	71.7	10.8	3.8	204.0	30.7	10.9
	IV.	Pre. Feb. 17-27	Atlas.	195.4	55.5	150.4	14.91	5.46	22.42	8.21	77.0	11.5	4.2	271.0	40.4	14.8
		Exp. Feb. 27-Mch. 17		350.0	100.3	276.5	15.03	5.52	41.56	15.26	79.0	11.9	4.4	275.7	41.4	15.2
	V.	Pre. Mch. 17-27	Corn-	190.1	54.2	140.0	14.72	5.11	20.61	7.15	73.7	10.8	3.8	258.3	38 0	13.2
		Exp. Mch. 27-Apl. 14	bran.	352.5	97.5	247.6	14.81	5.23	36.68	12.95	70.2	10.4	3.7	254.0	37.6	13.3
	VI.	Pre. Apl. 14-24	Atlas.	191.6	55.5	146.4	15.22	5.75	22.28	8.41	76.4	11 6	4.4	263.8	40.2	15.2
		Exp. Apl. 24-May 12		349.5	99.6	281.1	14.66	5.46	41.22	15.36	80.4	11.8	4.4	282.2	41.4	15.4
EFFIE.	I.	Pre. Nov. 25-Dec. 5	Atlas.	187.0	54.4	124.1	13.47	4.35	16.71	5.40	66.4	8.9	2.9	228.2	30.7	9.9
		Exp. Dec. 5-23		339.4	86.0	234.8	13.51	4.23	31.72	9.92	69.2	9.4	2.9	273.0	36.9	11.5
	II.	Pre. Dec. 23-Jan. 2	Corn-	200 9	53.8	105.5	13.89	4.52	14.65	4.77	52.5	7.3	2.4	196.1	27.2	8.9
		Exp. Jan. 2-20	bran.	360.9	96.7	200.5	13.76	4.48	27.58	8.98	55.6	7.6	2.5	207.4	28.5	9.3
	III.	Pre. Jan. 20-30	Atlas.	194.0	55.2	114.0	13.88	4.53	15.82	5.16	58 8	8.2	2.7	206.5	28.7	9.3
		Exp. Jan. 30-Feb. 17		348.7	99 5	228.8	13.67	4.36	31.28	9.98	65.6	9.0	2.9	230.0	31.4	10.0
	IV.	Pre. Feb. 17-27	Corn-	202.3	54.2	108.1	13 85	4.40	14.97	4.76	53.4	7.4	2.4	199.5	27.6	8.8
		Exp. Feb. 27-Mch. 17	bran.	363.3	97.6	195.0	13.77	4.38	26.85	8.55	53.7	7.4	2.4	199.8	27.5	8.8
	V.	Pre. Mch. 17-27	Atlas.	203.5	55.6	117.9	13.52	4.37	15.94	5.15	57.9	7.8	2.5	212.1	28.7	9.3
		Exp. Mch. 27-Apl. 14		374.9	100.2	206.8	13.68	4.45	28.30	9.21	55.2	7.6	2.5	206.4	28.2	9.2
	VI.	Pre. Apl. 14-24	Corn-	210.9	54.2	110.9	13.45	4.27	14.92	4.73	52.6	7.1	2.2	204.6	27.5	8.7
		Exp. Apl. 24-May 12	bran.	364.2	97.2	201.7	13.50	4.23	27.22	8.53	55.4	7.5	2.3	207.5	28.0	8.8

*In entire ration. †In experimental fodder.

Name of cow.	Period number.	6-WEEK PERIODS.	Experimental Fodder.	Dry Matter Eaten.*	Dry Matter Eaten.†	Milk.	Total Solids.	Fat.	Total Solids.	Fat.	WEIGHT OF PRODUCTS OBTAINED PER 100 LBS. OF DRY MATTER EATEN.					
											IN ENTIRE RATION.			IN EXPERIMENTAL FODDER.		
											Milk.	Total Solids.	Fat.	Milk.	Total Solids.	Fat.
				lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
ATALANTA.	I.	Pre. Nov. 25-Dec. 10	Atlas.	337.3	109.1	412.0	12.27	3.77	50.56	15.51	122.1	15.0	4.6	377.7	46.3	14.2
		Exp. Dec. 10-Jan. 6		641.5	183.7	772.7	12.37	3.69	95.59	28.48	120.5	14.9	4.4	420.6	52.0	15.5
	II.	Pre. Jan. 6-21	Corn-	366.4	107.6	362.3	12.57	3.63	45.54	13.15	98.9	12.4	3.6	336.7	42.3	12.2
		Exp. Jan. 21-Feb. 17	bran.	648.9	195.0	637.9	12.48	3.67	79 62	23.44	98 3	12.3	3.6	327.1	40.8	12.0
	III.	Pre. Feb. 17-Mch. 4	Atlas.	368.0	111.9	362.1	12.69	3.97	45.94	14.37	98.4	12.5	3.9	323.6	41.1	12.8
		Exp. Mch. 4-31		658.3	200.7	627.1	12.55	3.90	78.71	24.46	95.3	12.0	3.7	312.5	39.2	12.2
	IV.	Pre. Mch. 31-Apl. 15	Corn-	360.9	108.3	293.1	12.27	3.54	35.96	10.38	81.2	10.0	2.9	270.7	33.2	9.6
		Exp. Apl. 15-May 12	bran.	650.3	194.3	578.8	12.35	3.52	71.47	20.38	89.0	11.0	3.1	297.9	36.8	10.5
GOLDIE.	I.	Pre. Nov. 25-Dec. 10	Atlas.	324.2	109.1	225.6	15.04	5.54	33.92	12.50	69.6	10.5	3.9	206.8	31.1	11.5
		Exp. Dec. 10-Jan. 6		659.5	183.7	529.4	14.80	5.24	78.37	27.72	80.3	11.9	4.2	288.2	42.7	15.1
	II.	Pre. Jan. 6-21	Corn-	383.6	107.6	266.6	15.28	5.35	40.74	14.26	69.5	10.6	3.7	247.8	37.8	13.3
		Exp. Jan. 21-Feb. 17	bran.	648.4	195.0	434.3	15.43	5.54	66.99	24.04	67.0	10.3	3.7	222.7	34.4	12.3
	III.	Pre. Feb. 17-Mch. 4	Atlas.	350.0	111.9	252.2	15.71	5.85	39.62	14.74	72.1	11.3	4.2	225.4	35.4	13.2
		Exp. Mch. 4-31		649.9	200.7	486.2	15.46	5.57	75.14	27.08	74.8	11.6	4.2	242 3	37.4	13.5
	IV.	Pre. Mch. 31-Apl. 15	Corn-	351.5	108.3	243.8	15.40	5.60	37.55	13.66	69.4	10.7	3.9	225.1	34.7	12.6
		Exp. Apl. 15-May 12	bran.	615.7	194.3	460.2	15.14	5,33	69.67	24.53	74.7	11.3	4.0	236.9	35.9	12.6
PANSY.	I.	Pre. Nov. 25-Dec. 10	Corn-	323 1	106.5	274.4	13.69	4 36	37.55	14.97	84.9	11.6	3.7	257.7	35.3	11.2
		Exp. Dec. 10-Jan. 6	bran.	627.3	193.1	489.8	14.18	4.64	69.43	22.75	78.1	11.1	3.6	253.7	36.0	11.8
	II.	Pre. Jan. 6-21	Atlas.	368.3	110.7	293.9	14.18	4 73	41.68	13.90	79.8	11.3	3.8	265.5	37.7	12.6
		Exp. Jan. 21-Feb. 17		656 5	199.3	559.3	13.95	4.59	77.99	25.69	85.2	11.9	3.9	280 7	39.1	12.9
	III.	Pre. Feb. 17-Mch. 4	Corn-	378.7	111.5	276.6	14.49	4.81	40.08	13.29	73.0	10.6	3.5	248.1	35.9	11.9
		Exp. Mch. 4-31	bran.	663.3	195.0	410.6	14 74	5.10	60.52	20.94	61.9	9.1	3.2	210.6	31.0	10.7
	IV.	Pre. Mch. 31-Apl. 15	Atlas.	360.9	111.5	158.1	14.74	5 26	23.31	8.31	43.8	6.5	2.3	141.8	20.9	7.5
		Exp. Apl. 15-May 12		617.9	199.8	313.8	14.24	4.83	44.68	15.17	50.8	7.2	2.5	157.1	22.4	7.6

*In entire ration. †In experimental ration.

Name of cow.	Period number.	7 AND 8-WEEK PERIODS.	Experimental fodder.	Dry matter eaten.*	Dry matter eaten.†	Milk.	Total solids.	Fat.	Total solids.	Fat.	WEIGHT OF PRODUCTS OBTAINED PER 100 LBS. OF DRY MATTER EATEN. IN ENTIRE RATION. Milk.	Total solids.	Fat.	IN EXPERIMENTAL FODDER. Milk.	Total solids.	Fat.
				lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
MAZIE.	I.	Pre. Nov. 25-Dec. 12	Corn-	369.5	121.0	482.1	13.97	4.69	67.35	22.63	130.5	18.2	6.1	398.4	55.7	18.7
		Exp. Dec. 12-Jan. 13	bran.	762.0	229.1	898.1	13.72	4.50	123.11	40.40	117.9	16.2	5.3	392.1	53.7	17.6
	II.	Pre. Jan. 13-30	Atlas.	402.4	125.3	472.7	13.72	4.65	64.84	21.96	117.5	16.1	5.5	377.3	51.7	17.5
		Exp. Jan. 30 Mch. 3		742.3	236.8	816.2	13 72	4.66	111.94	38.01	110.0	15.1	5.1	344.7	47.3	16.1
	III.	Pre. Mch. 3-20	Corn-	393.7	122.8	377.9	13.85	4.53	52.32	17.11	96 0	13.3	4.3	307.7	42.6	13.9
		Exp. Mch. 30-Apl. 21	bran.	764.8	231.0	678.6	13.96	4.69	94.71	31.85	88.7	12.4	4.2	293.8	41.0	13.8
KITTIE.	I.	Pre. Nov. 25-Dec. 12	Atlas.	340.1	100.2	288.2	15.25	5.73	43.94	16.50	84.7	12.9	4.9	287.7	43.9	16.5
		Exp. Dec. 12-Jan. 13		695.2	235.6	554.0	15.17	5.55	84.06	30.74	79.7	12.1	4.4	235.2	35.7	13.0
	II.	Pre. Jan. 13-30	Corn-	378.8	122.1	231.2	15.46	5.61	35.75	12.96	61.0	9.4	3.4	189.4	29.3	10.6
		Exp. Jan. 30-Mch. 3	bran.	690.9	231.3	366.2	16.02	6.04	58.64	22.10	53.0	8 5	3.2	158.3	25.4	9.6
	III.	Pre. Mch. 3-20	Atlas.	370.0	125.5	194.1	16.24	6.43	31.51	12.47	52.5	8.5	3.4	154.7	25.1	9.9
		Exp. Mch. 20-Apl. 21		692.0	237.8	363.4	15.42	5.87	56.03	21.34	52.5	8.1	3.1	152.8	23.6	9.0
NANCY B.	I.	Pre. Nov. 25-Dec. 15	Atlas.	445.1	130.8	576.5	12.85	4.20	74.10	24.21	129.5	16.6	5.4	440.7	56.7	18.5
		Exp. Dec. 15-Jan. 20		983.1	263.2	1164.0	13.02	4.05	151.62	47.15	118.4	15.4	4.8	442.3	57.6	17.9
	II.	Pre. Jan. 20-Feb. 9	Corn-	505.2	144.0	556.2	13.24	4.25	73.67	23.66	110.1	14.6	4.7	386.3	51.2	16.4
		Exp. Feb. 9-Mch. 17	bran.	926.3	260.2	868.6	13.38	4 30	116.16	37.36	93.8	12.5	4.0	333.8	44.6	14.4
	III.	Pre. Mch. 17-Apl. 6	Atlas.	521.8	148.6	558.7	13.04	4.20	72.86	23.48	107.1	14.0	4.5	376.0	49.0	15.8
		Exp. Apl. 6-May 12		868.3	266.7	1057.6	12.72	3.85	134.53	40.74	121.8	15 5	4.7	396.6	50.5	15.3
MARJORY.	I.	Pre. Nov. 25-Dec. 15	Atlas.	425.5	130.8	332.2	15.03	5.73	49.94	19.02	78.1	11.7	4.5	254.0	38 2	14.5
		Exp. Dec. 15-Jan. 20		844.5	263.2	633.7	15.15	5.65	96.01	35 78	75.1	11.4	4.2	240.8	36.5	13.6
	II.	Pre. Jan. 20-Feb. 9	Corn-	445.3	144.0	318.7	15.31	5.56	48.79	17.71	71.6	11.0	4 0	221.3	33.9	12.3
		Exp. Feb. 9-Mch. 17	bran.	810.7	260.2	559.9	15.33	5.67	85.84	31.72	69.1	10.6	3.9	215.2	33.0	12.2
	III.	Pre. Mch. 17-Apl. 6	Atlas.	443.0	148.6	325.0	15.30	5.99	49.73	19.46	73.4	11.2	4.4	218.7	33.5	13.1
		Exp. Apl. 6-May 12		773 8	266.7	585.5	15.37	5.83	90.00	34.15	75.7	11.6	4.4	219 5	33.8	12.8
MINTA BELLA.	I.	Pre. Nov. 25-Dec. 15	Corn-	439.2	141 8	310.0	17.30	7.12	53.62	22.07	70.6	12.2	5.0	218.6	37.8	15.6
		Exp. Dec. 15-Jan. 20	bran.	871.5	258.1	628.0	17.06	6.91	107.11	43.38	72.1	12.3	5.0	243.3	41.5	16.8
	II.	Pre Jan. 20-Feb. 9	Atlas.	449.7	147.1	350.3	16.62	6.84	58.22	23.97	77 9	12 9	5.3	238.2	39.6	16.3
		Exp. Feb. 9-Mch. 17		799.7	267.3	620.8	16.70	6.78	103.67	42.09	77.6	13.0	5 3	232.3	38 8	15.7
	III.	Pre. Mch. 17-Apl. 6	Corn-	447.5	144.4	314.9	16.57	6.57	52.19	20.70	70.4	11.7	4.6	218.1	36.1	14.3
		Exp. Apl. 6-May 12	bran.	769.7	259.4	555.8	16.53	6.66	91.88	37.03	72.2	11.9	4.8	214.3	35.4	14.3

*In entire ration. †In experimental fodder.

Name of cow.	EQUAL BALANCE. Period number.	Weeks in period.	Experimental fodder.	PRELIMINARY PERIOD. Dry matter eaten.*	Dry matter eaten.†	Milk.	EXPERIMENTAL PERIOD. Dry matter eaten.*	Dry matter eaten.†	Milk.	Total solids.	Fat.	WEIGHT OF PRODUCTS OBTAINED PER 100 LBS. OF DRY MATTER EATEN. IN ENTIRE RATION. Total solids.	Fat.	IN EXPERIMENTAL FODDER. Milk.	Total solids.	Fat.			
				lbs	lbs	lbs	lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs			
RED TOP.	I.	5	C.-L.	268.2	85.8	341.5	596.5	167.1	735.1	12.89	4.05	94.77	29.78	123.2	15.9	5.0	439.9	56.7	17.8
	II.	7	A. G.	359.8	98.9	361.9	1048.3	305.0	1036.5	13.54	4.32	140.25	44.73	98.9	13 4	4.3	339.9	46.0	14.7
	III.	5	C.-L.	315.1	87.6	316.7	618.2	167.8	580.8	13.94	4.56	80.88	26.46	94.0	13.1	4.3	346.1	48.2	15.8
	IV.	4	A. G.	280.2	82.7	247.6	488.8	148.8	435.1	13.98	4.77	60.82	20.75	89.0	12.4	4.2	292.4	40.9	13.9
	V.	4	C.-L.	265.9	73.2	253.2	415.5	132.6	454.0	13.54	4.44	61.49	20.15	109.3	14.8	4.9	342.4	46.4	15.2
BROWNIE.	I.	5	C.-L.	258.6	85.8	153.2	562.5	167.1	329.6	14.91	5.35	49.15	17.64	58.6	8.7	3.1	197.3	29.4	10.6
	II.	7	A. G.	312.4	98.9	183.8	916.5	305.0	579.2	14.60	5.25	84.76	30.38	63.2	9.2	3.3	189.9	27.8	10.0
	III.	5	C.-L.	290.8	87.6	180.4	543.9	167.8	351.7	15.26	5.67	53.67	19.94	64.7	9.9	3.7	209.6	32.0	11.9
	IV.	4	A. G.	246.4	82.7	157.2	421.2	148.8	281.5	15.39	5.78	43.32	16.27	66.8	10.3	3.9	189 2	29.1	10.9
MAX BELLE.	I.	5	C.-L.	229.4	83.1	111.9	480.5	167.1	226.2	17.17	6.77	38.87	15.31	47.1	8.1	3.2	135.4	23.2	9.2
	II.	7	A. G.	260.4	98.9	111.4	778,9	305.0	336.4	17.30	6.97	58.20	23.44	43.2	7.5	3.0	110.3	19.1	7.7
	III.	5	C.-L.	244.2	87.6	113.4	474.7	167.8	217.9	17.70	7.35	38.57	16.04	45.9	8.1	3.4	129.9	23.0	9.6
	IV.	4	A. G.	219.5	82.7	98.1	389.9	148.8	169.2	17.26	6.93	29.20	11.73	43.4	7 5	3.0	113.7	19.6	7.9
	V.	4	C.-L.	208.0	73.2	87.8	342.2	130.8	159.3	16.83	6 82	26.81	10.87	46.6	7.8	3.0	121.8	20 5	8.3
BETTIE.	I.	5	C.-L.	261.8	85.8	127.4	556.4	167.1	269.8	14.11	4.89	38.07	13.19	48.5	6.8	2.4	161.5	22.8	7.9
	II.	7	A. G.	295.9	98.9	148.2	836.6	305.0	416.5	13.92	4.69	57.96	19.55	49.8	6·9	2.3	136.6	19.0	6.4
	III.	5	C.-L.	264.6	87.6	136.1	499.3	167.8	268.8	14.80	5.27	39.78	14.16	53.8	8.0	2.8	160.2	23.7	8.4
	IV.	4	A. G.	224.8	82.7	127.2	407.3	148.8	236.8	14.69	5.28	34.79	12.50	58.1	8.5	3.1	159.2	23.4	8.4
	V.	4	C.-L.	223.7	73.2	145.8	347.1	130.8	269.4	14.33	4.93	38.61	13.28	77.6	11.1	3.8	206.0	29.5	10.1
CLOVER.	I.	5	C.-L.	266.1	85.8	127.9	569.4	167.1	252.1	17.36	6.97	43.78	17.58	44.3	7.7	3.1	150.9	26.2	10.5
	II.	7	A. G.	313.7	98.9	146.7	952.8	305.0	434.9	16.45	6.54	71.53	28.46	45.7	7.5	3.0	142.6	23.5	9.3
	III.	5	C.-L.	289.7	87.6	116.4	540.4	167.8	228.1	17.23	6.99	39.31	15.95	42.2	7.3	3.0	135.9	23.4	9.5
JEANNIE.	I.	5	C.-L.	254.5	85.8	173.7	528.2	167.1	331.6	14.85	5.38	49.25	17.83	62.8	9.3	3.4	198.5	29.5	10.7
	II.	7	A. G.	284.9	98.9	162.2	854.3	305.0	467.4	15.07	5.69	70.44	26.59	54.7	8.2	3.1	153.3	23.1	8.7
	III.	5	C.-L.	265.9	87.6	133.1	516.4	167.8	210.7	15.60	6 05	32.87	12.75	40.8	6.4	2.5	125.6	19.6	7.6
EULALIE.	I.	5	C.-L.	268.2	85 8	93.5	610.7	167.1	154.5	14.80	5.35	22.86	8.27	25.3	3.7	1.4	92.5	13.7	5.0
	II.	7	A. G.	345.3	98.9	80.0	992.1	305.0	213.2	15.10	5.52	32.19	11.76	21.5	3.2	1.2	69.9	10.6	3.9
	III.	5	C.-L.	298.5	87.6	58.2	579.6	167.8	77.8	15.78	6.17	12.28	4.80	13.4	2.1	0.8	46.4	7.3	2.9
KIWORA.	I.	5	C.-L.	239.0	85.8	83.2	486.0	167.1	143.9	15.61	5.84	22.47	8.41	29.6	4.6	1.7	86.1	13.4	5.0
	II.	7	A. G.	268.3	98.9	70.5	790.4	305.0	206.0	15.91	6.16	32.78	12.68	26.1	4.1	1.6	67.6	10.7	4.2
	I.	5	C.-L.	245.8	87.6	65.7	457.2	167.8	121.4	16.05	6.45	19.49	7.83	26.6	4.3	1.7	72.4	11.6	4.7
JULIA.	I.	5	C.-L.	261.0	85.8	130.0	530 7	167.1	250.4	16.94	6.56	42.42	16.43	47.2	8.0	3.1	149.9	25.4	9.8
	II.	7	A. G.	285.9	98.9	127.7	830.6	305.0	408.2	16.41	6.32	66.97	25.78	49.1	8.1	3.1	133.8	22.0	8.5
	III.	5	C.-L.	260.4	87.6	136.1	490.4	167.8	245.9	16.94	6.66	41.65	16.38	50.1	8.5	3.3	146.6	24.8	9.8

*In entire ration. †In experimental fodder.

EXP'TL ERROR.		PRELIMINARY PERIOD.			EXPERIMENTAL PERIOD.							WEIGHT OF PRODUCTS OBTAINED PER 100 LBS. OF DRY MATTER EATEN.					
												IN ENTITE RATION.			IN EXPERIMENTAL FODDER.		
Name of cow.	Period number.	Dry matter eaten.*	Dry matter eaten.†	Milk.	Dry matter eaten.*	Dry matter eaten.†	Milk.	Total solids.	Fat.	Total solids.	Fat.	Milk.	Total solids.	Fat.	Milk.	Total solids.	Fat.
SALIDA.	I.	194.3	27.5	85.0	337.6	132.7	136.6	15.08	5 38	20.60	7.35	40.5	6.1	2.2	102.9	15.5	5.5
	II.	182.6	73.2	78.8	337.8	143.6	122.4	15.46	5.56	18,92	6 81	36.2	5.6	2.0	85.2	13.2	4.7
	III.	185.5	79.7	58.4	333.0	137.1	96.2	15 39	5.68	14.80	5.46	28.9	4.5	1.6	70.2	10.8	4.0
	IV.	181.8	73.7	50.4	340.9	138.1	80.3	15.34	5.72	12.32	4.59	23.6	3.6	1.4	58.1	8,9	3.3
	V.	179.8	67.5	46.7	334.3	138.6	91.8	14.92	5.40	13.70	4.96	27.5	4.1	1.5	66.2	9.9	3.6
	VI.	177.7	71.3	51.0	302.3	111.5	93.9	14.63	5.18	13.74	4.86	31.0	4.5	1.6	84.2	12.3	4.4
HELENA.	I.	194.5	28.6	87.6	337.0	131.2	172.9	15.57	5.64	26.92	9.76	51.3	8.0	2.9	131.8	20.5	7.4
	II.	182.0	70.9	95.6	334.2	135.8	155.8	15.96	6.00	24.86	9.34	46.6	7.4	2.8	114.7	18.3	6.9
	III.	187.8	79.7	85.9	334 7	131.9	152.4	16.00	6.02	24.39	9,18	45.5	7.3	2.7	115.5	18.5	7.0
	IV.	183.0	71.3	81.8	343.5	135.5	144.1	16.16	6.22	23.28	8.96	42.0	6.8	2.6	106.4	17.2	6.6
	V.	165.7	55.2	75.6	312 2	111.3	143.2	16.26	6.35	23.28	9.09	45.9	7.5	2.9	128.7	20.9	8 2
	VI.	158.2	50.1	80.0	294.3	93.6	158.2	15.70	5.85	24.83	9.25	53.8	8.4	3.1	169.0	26.5	9.9
DAISY.	I.	192.6	27.5	65.4	324.3	122.9	135.3	16.81	6.57	22.74	8.89	41.7	7.0	2.7	110.1	18.5	7.2
	II.	168.2	59.7	59.6	308.3	115.8	100.8	17.49	6.98	17.63	7.03	32.7	5.7	2.3	87.1	15.2	6.1
	III.	179.9	74.1	53.7	311 3	116.2	85.2	17.57	7.11	14 97	6.06	27.5	4.8	1.9	73.3	12.9	5.2
	IV.	175.7	65.8	45 6	318.2	116.3	68.5	17.18	6.99	11.77	4.79	21.5	3.7	1.5	58.9	10.1	4.1
	V.	160.5	50.0	37.8	295.1	99.4	63.9	16.50	6.54	10.54	4.18	21.7	3.6	1.4	64.3	10.6	4.2
	VI.	139.0	37.9	33.8	253.9	60.4	64.8	16.11	6.34	10.44	4.11	25.5	4.1	1.6	107 3	17.3	6.8
REGINA.	III.	174.7	61.6	154.5	371.2	106.9	298.1	12.00	3.42	35.76	10.19	80.3	9.6	2.7	278.9	33.5	9.5
	IV.	225.2	71.3	165.9	389.4	118.9	300.1	12.53	3.63	37.59	10.88	77.1	9.6	2.8	252.4	31.6	9.2
	V.	210.7	59.7	166.4	379.1	112.0	276 5	12 34	3.53	34.13	9.77	72.9	9.0	2.6	246.9	30.5	8.7
	VI.	189.6	50,1	157.4	362.5	100.2	290.7	12.53	3.63	36.42	10.54	80.2	10.0	2.9	290.2	36.4	10.5
ROWENA.	I.	224.3	18.4	104.7	431.9	126.4	207.3	15.74	5.63	32.64	11.68	48.0	7.6	2.7	164.0	25.8	9.2
	II.	246.3	81.5	121.2	446 6	153.7	205.5	15.88	5.69	32.64	11.70	46.0	7.3	2.6	133.7	21.2	7.6
	III.	239 4	79.6	100.4	413.8	128.8	135.0	16.29	5.86	21.99	7.91	32.6	5.3	1.9	104.8	17.1	6.1
BESS.	I.	228,1	22.2	160.0	446.2	139.0	318.1	15.35	5.67	48.84	18.04	71.3	10.9	4.0	228.8	35.1	13.0
	II.	256.9	93.8	185.2	444.0	161.3	322.5	15.84	5.95	51.09	19.20	72.6	11.5	4.3	200.0	31.7	11,9
	III.	243.2	85.9	169.8	434.5	146.9	269.7	15.68	5.85	42.28	15.77	62.1	9.7	3.6	183.6	28.8	10.7
GOLDEN-ROD.	I.	229.1	32.8	70.6	416.1	148.9	121.8	17.46	7.22	21.27	8.80	29.3	5 1	2.1	81.9	14.3	5.9
	II.	222.0	78.8	58.9	402.1	144.8	89.4	17.77	7 14	15.89	6.62	22.2	4.0	1.6	61.7	11.0	4.6
	III.	223.8	81.5	40.3	396.2	137.1	51.7	18.26	7.89	9.44	4.08	13.1	2.4	1.0	37.7	6.9	3.0
IDABELLA.	I.	231.2	29.7	122.1	385.0	121.3	232.4	15 93	6.06	37.01	14.08	60.4	9.6	3.7	191.6	30.5	11.6
	II.	167.9	37.7	105.9	331.6	84.5	178.4	16.05	6.11	28.63	10.90	53.8	8.6	3.3	211.1	33.9	12.9
	III.	194.2	53.5	90.4	349.1	93.5	135.3	16.32	6.31	22.08	8.54	38.8	6.3	2.5	144.7	23.6	9.1
BESSETTE.	I.	221.4	26.0	136.9	399.4	132.2	270.8	15.87	5.87	42.96	15.89	67.8	10.8	4.0	204.8	32.5	12.0
	II.	212.9	71.5	149.8	392.4	137.6	236.8	16.33	6.23	38.66	14.75	60.3	9.9	3.8	172.1	28 1	10.7
	III.	223.5	82.8	122.9	405.4	142.9	189.1	17.26	6.73	32 63	12.73	49.6	8.0	3.1	132.3	22,8	8.9

*In entire ration. †In experimental fodder.

VI. DIFFERENCE TABLES. (*a*) PERIOD LENGTH; (*b*) EQUAL BALANCE; (*c*) EXPERIMENTAL ERROR.

(Showing differences in experimental feeding between the average of the results of two periods on one ration and those actually obtained with another ration in the intervening period.)

It seems necessary to accompany the "difference tables" with certain explanatory notes in order that they may be clearly understood.

When a cow eats a certain ration during a feeding period, another during a second period, returning to the first ration for a third period, all three being of equal lengths, and, so far as may be, all other things being equal, it is fair to assume, and, in the discussion of feeding experiments is usually assumed, that the average of the results obtained during the first and third periods on the ration then fed would be those which would have been found during the second period had the feeding continued on one ration. A comparison of this average with the results actually obtained with another ration serves to show the relative value of the different fodders and feeds. The comparison of these averages and of the actual results form the data presented in the "difference tables."

The first comparison of the record of the cow Acme is given in full in order to show more clearly just what is meant by the figures in the "difference tables."

Record of Cow "Acme."	Total Dry Matter Eaten.	Dry Matter Eaten in Experimental Fodder.	Milk.	Total Solids.	Fat.	Weight of Products Obtained per. 100 lbs. of Dry Matter.					
						In Entire Ration.			In Experimental Fodder.		
						Total Solids.	Fat.	Milk.	Total Solids.	Fat.	Milk.
	lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Average of actual records for period I. and III. (Atlas).....	407.3	125.1	512.0	12.50	3.95	63.93	20.19	125.7	15.7	5.0	413.2
Actual record for period II. (Corn and bran)...	400.3	129.0	434.8	12.77	3.94	55.52	17.13	108.6	13.9	4.3	337.1
Record made upon corn and bran ± the averages of those made on Atlas gluten meal.....	—7.0	+3.9	-77.2	+0.27	-0.01	-8.41	-3.06	-17.1	-1.8	-0.7	-76.1

Record of Cow "Acme."	In Experimental Fodder.		
	Total Solids.	Fat.	
	lbs.	lbs.	
Average of actual records for period I. and III. (Atlas).....	51.6	16.3	
Actual record for period II. (Corn and bran)...	43.0	13.3	
Record made upon corn and bran ± the averages of those made on Atlas gluten meal.....	-8.6	-3.0	

The first horizontal line of figures shows the average of the records of dry matter eaten, of milk, solids, and fat given, etc., obtained during the experimental portions of the first and third 4-week feeding periods, while the cow was eating the Atlas ration. The second horizontal line of figures shows the actual records of dry matter, milk, etc., obtained during the experimental portion of the second 4-week period, while the cow was eating the corn and bran ration. The third horizontal line shows the amounts, greater or less, as the case may be, of dry matter eaten, milk given, etc, when the corn and bran ration was fed as compared with the average of the records on the Atlas ration. These differences, furnish a measure of the relative value of the two rations, it being assumed, as stated above, that the averages correctly indicate the consumption and production which would have occurred during the intervening period had the ration remained unchanged.

The figures of the third horizontal line will be found at the beginning of the "difference tables" upon page 212. All the differences recorded in the tables on pages 212-217 inclusive and upon page 220 were obtained in the manner indicated.

The outcome of the experiment is also well shown by adding the total products for each period and for each calculated period. Thus, for example, in the case of the three cows, Acme, Effie and Dora, fed in six 4-week periods, incuding six 18-days experimental portions, a comparison of 216 days feeding for one cow on each ration may be made and neither side of the comparison suffer from the effects of advancing lactation, this being equalized. The following data will give the equivalent of 216 days feeding on corn and bran:

Acme; periods II and IV on corn and bran,	36 days' feeding
Dora; " III and V " " "	36 " "
Effie; " II and IV " " "	36 " "
Acme; average of periods II and IV and average of periods IV and VI on corn and bran; equivalent respectively to what might reasonably have been expected to have been the products in periods III and V had the feeding upon corn and bran continued,	36 " "
Dora; average of periods I and III and average of periods III and V on corn and bran; equivalent, etc., to periods II and IV on corn and bran,	36 " "
Effie; average of periods II and IV and average of periods IV and VI on corn and bran; equivalent, etc., to periods III and V on corn and bran,	36 " "
Equivalent to	216 days' feeding

The following data will give the equivalent of 216 days' feeding on Atlas Gluten Meal.

Acme; periods III and V on Atlas gluten meal,	36 days' feeding
Dora; periods II and IV " " "	36 " "
Effie; periods III and V " " "	36 " "
Acme; periods I and III and average of periods III and V on Atlas gluten meal; equivalent, etc., to periods II and IV on Atlas gluten meal,	36 " "
Dora; average of periods II and IV and average of periods IV and VI on Atlas gluten meal; equivalent, etc., to periods III and V on Atlas gluten meal,	36 " "
Effie; average of periods I and III and average of periods III and V on Atlas gluten meal; equivalent, etc., to periods II and IV on Atlas gluten meal,	36 " "
Equivalent to	216 days' feeding

This calculation gives the record of each cow on each ration for the selfsame days of the experimental portions of periods II, III, IV and V.

The figures appearing upon pages 212-217 under the caption "weight of products obtained per 100 pounds of dry matter," which show the results calculated to the prolonged feeding of a single cow, are not properly described by this caption. They represent the weights of products obtained per as many times 100 pounds of dry matter as comparisons appear. In the 4-week period test, 12 comparisons appear, in the 6-week test 6, in the 7-week test, 3, in the 8-week test, 3, in the equal balance test, 16, in the experimental error test ,20. As the insertion of new headings would have been awkward, the caption, which is strictly correct for the main portion of each table, is allowed to stand.

The average per cents. of total solids and fat are obtained by addition and not by cross-division. This gives each cow a similar value in the final results instead of giving greater weights to the cow giving the most and a lesser weight to her who gives the least.

DIFFERENCE TABLES.

(a) PERIOD LENGTH.

4-WEEK PERIODS.

Names of cows.		Total dry matter eaten.	Dry matter eaten in experimental fodder.	Milk.	Total solids.	Fat.	WEIGHT OF PRODUCTS OBTAINED PER 100 LBS. OF DRY MATTER. IN ENTIRE RATION. Total solids.	Fat.	Milk.	Total solids.	Fat.	IN EXPERIMENTAL FODDER. Milk.	Total solids.	Fat.
		lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
Acme.....	±	− 7.0	+ 3.9	−77.2	+0.27	−0.01	− 8.41	− 3.06	− 17.1	− 1.8	−0.7	− 76.1	− 8.6	− 3.0
		+ 2.5	− 3.2	−71.1	+0.26	−0.04	− 8.04	− 3.03	− 18.2	− 2.1	−0.8	− 47.1	− 5.3	− 2.0
Dora.....		+18.7	+30.1	−30.4	−0.01	−0.23	− 4.62	− 2.29	− 12.5	− 1.9	−0.9	− 92.2	−13.9	− 5.5
		+ 2.7	− 2.5	−31.2	−0.04	−0.26	− 4.71	− 2.36	− 9.5	− 1.5	−0.7	− 25.0	− 3.8	− 2.0
Effie.....		+16.8	+ 3.9	−31.3	+0.17	+0.18	− 3.92	− 0.97	− 11.8	− 1.6	−0.4	− 44.1	− 5.7	− 1.5
		+ 1.5	− 2.3	−22.8	+0.09	−0.03	− 2.94	− 1.05	− 6.7	− 0.9	−0.3	− 18.4	− 2.3	− 0.8
Totals....	Corn and bran (actual) ± Atlas gluten (calculated).	+35.2	+29.9	-264.0			−32.64	−12.76	− 75.8	− 9.8	−3.8	−302.8	−39.6	−14.8
Averages		+ 5.9	+ 5.0	−44.0			− 5.44	− 2.13	− 12.6	− 1.8	−0.6	− 50.5	− 6.6	− 2.5
Percentage differences		+ 2	+ 4	−13			−12	−14	− 15	−14	−16	− 17	−16	−18
Acme.....	±	+ 2.4	+ 3.1	+65.5	−0.27	−0.01	+ 7.23	+ 2.59	+ 15.5	+ 1.7	+0.6	+ 42.0	+ 4.6	+ 1.6
		− 3.8	+ 4.1	+28.0	+0.07	+0.33	+ 3.86	+ 2.41	+ 7.8	+ 1.0	+0.6	+ 12.3	+ 1.7	+ 1.4
Dora.....		− 6.4	−13.7	+34.8	+0.06	+0.28	+ 5.42	+ 2.76	+ 11.1	+ 1.7	+0.8	+ 61.3	+ 9.4	+ 4.1
		−11.2	−13.5	+20.1	+0.09	+0.24	+ 3.25	+ 1.73	+ 8.0	+ 1.3	+0.6	+ 46.7	+ 7.2	+ 3.1
Effie.....		−13.4	+ 2.3	+31.0	−0.10	−0.07	+ 4.06	+ 1.21	+ 10.9	+ 1.5	+0.4	+ 26.4	+ 3.4	+ 0.9
		+11.1	+ 2.8	+ 8.4	+0.04	+0.14	+ 1.26	+ 0.67	+ 0.6	+ 0.1	+0.1	+ 2.7	+ 0.4	+ 0.4
Totals....	Atlas gluten (actual) ± corn and bran (calculated).	−21.3	−14.9	+ 187.8			+25.08	+11.37	+ 53.9	+ 7.3	+3.1	+191.4	+26.7	+11.5
Averages		− 3.6	− 2.5	+31.3			+ 4.18	+ 1.90	+ 9.0	+ 1.2	+0.5	+ 31.9	+ 4.5	+ 1.9
Percentage differences		− 1	− 2	+11			+11	+15	+ 12	+12	+15	+ 15	+13	+17

RESULTS OF 216 DAYS' EXPERIMENTAL FEEDING ON EACH RATION.

Corn and bran.	4503	1362	3399	13.83	4.56	465.43	152.20	897.0	123.4	40.7	2959.1	406.7	133.7	
Atlas gluten meal.....	4447	1317	3851	13.77	4.66	523.15	176.33	1026.7	140.5	47.7	3453.3	473.0	160.0	
Atlas gluten meal ± corn and bran.	− 56	− 45	+ 452	−0.06	+0.10	+57.72	+24.13	+129.7	+17.1	+7.0	+494.2	+66.3	+26.3	
Percentage differences.....	− 1	− 3	+ 13	0	+2	+12	+16	+ 14	+14	+17	+ 17	+16	+20	

Ratio of per cent. of fat to per cent. of solids not fat: Corn and bran ration, 1 :2.03; Atlas gluten meal ration, 1 :1.95.

6-WEEK PERIODS.

Names of cows.		Total dry matter eaten.	Dry matter eaten in experimental fodder.	Milk.	Total solids.	Fat.	Total solids.	Fat.	WEIGHT OF PRODUCTS OBTAINED PER 100 LBS. OF DRY MATTER. IN ENTIRE RATION. Milk.	Total solids.	Fat.	EXPERIMENTAL FODDER. Milk.	Total solids.	Fat.
	±	lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	l.
Atalanta...	Corn and bran (actual) ± Atlas gluten (calculated).	— 1.0	+ 2.8	—62.0	+0.02	—0.13	— 7.53	— 3.03	— 9.6	— 1.2	—0.5	— 39.5	— 4.8	— 1.9
Goldie.....		— 6.3	+ 2.8	—73.5	+0.30	+0.13	— 9.77	— 3.36	— 10 6	— 1.5	—0.5	— 42.6	— 5.7	— 2.0
Fanny.....		+26.1	— 4.6	—26.0	+0.64	+0.39	— 0.82	+ 0.51	— 6.1	— 0.5	0.0	— 8.3	+ 0.2	+ 0.4
Totals..		+18.8	+ 1.0	161.5			—18.12	— 5.88	— 26.3	— 3.2	—1.0	— 90.4	—10.3	— 3.5
Averages		+ 6.	+ 0.3	—53.8			— 6.04	— 1.96	— 8.8	— 1.1	—0.3	— 30.1	— 3.4	— 1.2
Percentage differences		+ 1	0	—10			— 8	— 8	— 10	— 9	—9	— 11	— 9	— 9
Atalanta...	Atlas gluten (actual) ± corn and bran (calculated).	+ 8.7	+ 6.0	+18.7	+0.13	+0.30	+ 3.16	+ 2.55	+ 1.6	+ 0.3	+0.3	0.0	+ 0.4	+ 0.9
Goldie.....		+17.8	+ 6.0	+38.9	+0.17	+0.13	+ 6.81	+ 2.79	+ 3.9	+ 0.8	+0.3	+ 12.5	+ 2.2	+ 1.0
Fanny.....		+11.2	+ 5.2	109.1	—0.51	—0.28	+13.01	+ 3.85	+ 15.2	+ 1.8	+0.5	+ 48.5	+ 5.6	+ 1.6
Totals....		+37.7	+17.2	+ 166.7			+22.98	+ 9.19	+ 20.7	+ 2.9	+1.1	+ 61.0	+ 8.2	+ 3.5
Averages		+12.6	+ 5.7	+55.6			+ 7.66	+ 3.06	+ 6.9	+ 1.0	+0.4	+ 20.3	+ 2.7	+ 1.2
Percentage differences		+ 2	+ 3	+11			+11	+14	+ 9	+ 9	+10	+ 8	+ 8	+10

RESULTS OF 162 DAYS' EXPERIMENTAL FEEDING ON EACH RATION.

Corn and bran.	3888	1168	2989	14.14	4.70	415.98	136.46	461.8	64.3	21.2	1534.5	213.7	70.0
Atlas gluten meal.....	3907	1185	3317	13.94	4.66	457.08	151.53	508.8	70.2	23.3	1686.3	232.2	77.1
Atlas gluten meal ± corn and bran.....	+ 19	+ 17	+ 328	—0.20	—0.04	+41.10	+15.07	+ 47.0	+ 5.9	+2.1	+151.8	+18.5	+ 7.1
Percentage differences.....	0	+ 1	+ 11	—1	—1	+10	+11	+ 10	+ 9	+10	+ 10	+ 9	+10

Ratio of per cent. of fat to per cent. of solids not fat: Corn and bran ration, 1 : 2.01; Atlas gluten meal ration. 1 :1.99.

7-WEEK PERIODS.

Names of cows.		Total dry matter eaten.	Dry matter eaten in experimental fodder.	Milk.	Total solids.	Fat.	Total solids.	Fat.	WEIGHT OF PRODUCTS OBTAINED PER 100 LBS. OF DRY MATTER. IN ENTIRE RATION. Milk.	Total solids.	Fat.	IN EXPERIMENTAL FODDER. Milk.	Total solids.	Fat.
		lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
Kittie.....	C. & B. (ac.) ± A. G. (cal.)	— 2.6	— 5.4	—92.5	+0.72	+0.33	—11.41	— 3.94	—13.1	— 1.6	—0.6	—35.7	— 4.3	— 1.4
Percentage differences		0	— 2	—20			—16	—15	—20	—16	—16	—18	—15	—18
Maizie.....	A. G. (ac.) ± C. & B. (cal.)	—21.1	+ 6.7	+27.8	—0.12	+0.06	+ 3.03	+ 1.88	+ 6.7	+ 0.8	+0.3	+ 1.7	— 0.1	+ 0.4
Percentage differences		— 3	+ 3	+ 3			+ 3	+ 5	+ 6	+ 6	+6	0	0	+ 3

RESULTS OF 64 DAYS' EXPERIMENTAL FEEDING ON EACH RATION.

Corn and bran.	1454	461	1155	1493	5.32	167.55	56.23	156.3	22.8	8.0	501.3	72.8	25.3	
Atlas gluten meal.....	1436	474	1275	1451	5.19	181.99	64.05	175.1	25.2	8.9	538.7	77.0	27.6	
Atlas gluten meal ± corn and bran.....	— 18	+ 13	+ 120	—0.42	—0.13	+14.44	+ 5.82	+ 18.8	+ 2.4	+0.9	+ 37.4	+ 4.2	+ 1.8	
Percentage differences.....	— 1	+ 3	+ 10	—3	—2	+ 9	+10	+ 12	+11	+11	+ 7	+ 6	+ 7	

Ratio of per cent. of fat to per cent. of solids not fat: Corn and bran ration, 1:1.81; Atlas gluten meal ration, 1:1.80.

8-WEEK PERIODS.

Names of cows.		Total dry matter eaten.	Dry matter eaten in experimental fodder.	Milk.	Total solids.	Fat.	Total solids.	Fat.	WEIGHT OF PRODUCTS OBTAINED PER 100 LBS. OF DRY MATTER. IN ENTIRE RATION. Milk.	Total solids.	Fat.	IN EXPERIMENTAL FODDER. Milk.	Total solids.	Fat.
	±	lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Nancy B...	Corn and bran (act.) Atlas gluten (calc.)	+ 0.6	— 4.8	-242.2	+0.51	+0.35	—26.92	— 6.59	— 26.3	— 3.0	—0.8	— 85.7	— 9.5	— 2.2
Marjory...		+ 1.5	— 4.8	-49.7	+0.07	—0.07	— 7.17	— 3.25	— 6.3	— 0.9	—0.4	— 15.0	— 2.2	— 1.0
Totals. ..		+ 2.1	— 9.6	291.9			—34.09	— 9.84	— 32.6	— 3.9	—1.2	—100.7	—11.7	— 3.2
Averages		+ 1.1	— 4.8	146.0			—17.05	— 4.92	— 16.3	— 2.0	—0.6	— 50.4	— 5.9	— 1.6
Percenta e differences		0	— 2	—17			—14	—12	— 16	—16	—13	— 16	—13	—11
Minta Bella	A. G. (ac.) + C. & B. (cal.)	—20.9	+ 8.5	+28.9	—0.10	—0.01	+ 4.17	+ 1.88	+ 5.4	+ 1.1	+0.4	+ 3.5	+ 0.3	+ 0.1
Percentage differences		— 2	+ 3	+ 5			+ 4	+ 4	+ 7	+ 9	+8	+ 1	+ 1	+ 1

RESULTS OF 112 DAYS' EXPERIMENTAL FEEDING ON EACH RATION.

Corn and bran.	2558	779	2020	15.17	5.59	301.49	109.29	235.1	35.2	12.8	777.8	116.1	42.2	
Atlas gluten meal.....	2535	797	2341	14.94	5.49	339.76	121.00	273.1	40.0	14.3	881.5	128.1	45.5	
Atlas gluten meal ± corn and bran.....	— 23	+ 18	+ 321	—0.23	—0.10	+38.27	+11.71	+ 38.0	+ 4.8	+1.5	+104.1	+12.0	+ 3.3	
Percentage differences.....	— 1	+ 2	+ 16	—1	—2	+13	+11	+ 16	+14	+12	+ 13	+10	+ 8	

Ratio of per cent. of fat to per cent. of solids not fat: Corn and bran ration, 1 :1.71; Atlas Gluten meal ration, 1 :1.72,

(*b*) EQUAL BALANCE.

Names of cows.		Total dry matter eaten.	Dry matter eaten in experimental fodder.	WEIGHT OF PRODUCTS OBTAINED DRY PER 100 LBS. OF MATTER. IN ENTIRE RATION. Milk.	Total solids.	Fat.	IN EXPERIMENTAL FODDER. Total solids.	Fat.	Milk.	Total solids.	Fat.	Milk.	Total solids.	Fat.
		lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Red Top...	Atlas gluten meal (actual) + cottonseed-linseed (calculated).	+ 34.7	+ 17.3	—10.6	+0.12	+0.01	— 0.50	— 0.25	— 9.7	— 1.1	— 0.4	— 53.1	— 6.5	— 2.1
		+ 39.1	+ 16.8	—19.2	+0.24	+0.27	— 1.58	+ 0.32	— 12.7	— 1.6	— 0.4	— 51.9	— 6.4	— 1.6
Max Belle.		+ 5.2	+ 17.3	—10.1	—0.14	—0.09	— 1.98	— 0.87	— 3.3	— 0.6	— 0.3	— 22.4	— 4.0	— 1.7
		+ 33.0	+ 17.7	+ 4.3	—0.01	—0.16	+ 0.70	+ 0.02	— 2.9	— 0.5	— 0.3	— 12.2	— 2.2	— 1.1
Bettie.....		— 6.1	+ 17.3	— 8.2	—0.54	—0.39	— 2.26	— 1.19	— 1.4	— 0.5	— 0.3	— 24.2	— 4.3	— 1.8
		+ 38.3	+ 17.7	— 3.1	+0.12	+0.18	— 0.07	+ 0.32	— 7.6	— 1.1	— 0.2	— 23.9	— 3.2	— 0.9
Brownie...		+ 12.3	+ 17.3	+15.2	—0.49	—0.26	+ 1.00	+ 0.08	+ 1.5	— 0.1	— 0.1	— 13.6	— 2.9	— 1.3
Clover.....		+ 37.3	+ 22.1	+30.3	—0.85	—0.44	+ 2.92	+ 0.92	+ 2.4	0.0	— 0.1	— 0.8	— 0.7	— 0.7
Jeannie....		+ 8.7	+ 22.1	+19.2	—0.16	—0.03	+ 2.73	+ 1.24	+ 2.9	+ 0.3	+ 0.1	— 8.8	— 1.5	— 0.5
Eulalie....		+ 21.6	+ 22.1	+16.3	—0.19	—0.24	+ 2.44	+ 0.78	+ 2.1	+ 0.3	+ 0.1	+ 0.4	+ 0.1	— 0.1
Kinkora...		+ 19.7	+ 22.1	— 4.6	+0.08	+0.01	— 0.60	— 0.24	— 2.0	— 0.4	— 0.1	— 11.7	— 1.8	— 0.7
Julia.....		+ 5.8	+ 22.1	+ 5.5	—0.53	—0.29	— 0.41	— 0.38	+ 0.4	— 0.2	— 0.1	+ 14.5	— 3.1	— 1.3
Totals....		+249.6	+231.9	+35.0			+ 2.39	+ 0.75	— 30.3	— 5.5	— 2.1	—236.7	—36.5	—13.8
Averages..		+ 20.8	+ 11.0	+ 2.9	—0.20	—0.12	+ 0.20	+ 0.66	— 2.5	— 0.5	— 0.2	— 19.7	— 3.0	— 1.2
Percentage differences		+ 4	+ 11	+ 1	—1	—2	+ 1	0	— 5	— 6	— 6	— 12	—13	—13
Red Top ..	Cottonseed-linseed (actual) + Atlas gluten meal (calculated).	— 15.6	— 17.3	—15.2	+0.18	+0.01	— 1.23	— 0.55	0.0	+ 0.2	0.0	+ 29.9	+ 4.7	+ 1.5
Max Belle.		— 13.0	— 17.3	+ 4.0	+0.43	+0.40	+ 1.42	+ 0.98	+ 2.6	+ 0.6	+ 0.4	+ 17.9	+ 3.6	+ 1.8
Bettie.....		— 16.4	— 17.3	— 9.3	+0.49	+0.28	— 0.36	+ 0.07	— 0.2	+ 0.3	+ 0.1	+ 12.3	+ 2.5	+ 1.0
Brownie...		— 7.9	— 17.3	— 6.5	+0.26	+0.15	— 0.28	+ 0.08	— 0.3	+ 0.1	+ 0.1	+ 20.0	+ 3.5	+ 1.4
Totals....		— 52.9	— 69.2	—27.0			— 0.45	+ 0.68	+ 2.1	+ 1.2	+ 0.6	+ 80.1	+14.3	+ 5.7
Averages...		— 13.2	— 17.3	— 6.8	+0.34	+0.21	— 0.11	+ 0.17	+ 0.5	+ 0.3	+ 0.2	+ 20.0	+ 3.6	+ 1.4
Percentage differences		— 3	— 13	— 3	+2	+4	0	+ 1	+ 1	+ 3	+ 4	+ 9	+11	+12

RESULTS OF 331 DAYS EXPERIMENTAL FEEDING ON EACH RATION.

Atlas gluten meal.....	7500	2582	4209	15.29	5.65	628.09	227.24	899.0	134.4	48.8	2674.9	398.3	143.6	
Cottonseed-Linseed.....	7199	2281	4144	15.52	5.80	625.30	227.08	931.4	144.1	51.5	1991.8	449.7	163.1	
Atlas + Cottonseed-Linseed.	+ 301	+ 301	+ 62	—0.23	—0.15	+ 2.79	+ 0.16	— 32.4	— 9.7	— 2.7	—316.9	—51.4	—19.5	
Percentage differences	+ 4	+ 12	+ 1	—1	—3	0	0	— 4	— 7	— 6	— 12	—13	—14	

Ratio of per cent. of fat to per cent. of solids not fat; Atlas gluten meal ration 1 : 1.71; cottonseed-linseed ration, 1 ; 1.68.

(*c*) EXPERIMENTAL ERROR.

Names of cows.	Number of periods	Total dry matter eaten.	Dry matter eaten in experimental ration.	Milk.	Total solids.	Fat.	Total solids	Fat.	WEIGHT OF THE PRODUCTS OBTAINED PER 100 LBS. OF DRY MATTER. IN ENTIRE RATION. Milk.	Total solids.	Fat.	IN EXPERIMENTAL FODDER. Milk.	Total solids.	Fat.
		lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Salida	II + I and III	+ 2.5	+ 8.7	+ 6.0	+0.23	+0.03	+1.22	+0.40	+1.5	+0.3	+0.1	— 1.4	0.0	—0.1
"	IV + III and V	+ 7.2	+ 0.2	- 13.7	+0.19	+0.18	—1.93	—0 62	—4.6	—0.7	— 0.2	—10.1	—1.5	—0.5
Helena	III + II and IV	— 4.2	— 3.8	+ 2.4	- 0.06	—0.09	+0.32	+0.03	+1.2	+0.2	0.0	+ 4.9	+0.7	+0.2
"	V + IV and VI	— 6.7	— 3.3	— 8.0	+0.33	+0.31	—0.78	—0.02	—2.0	—0.1	0.0	— 9.0	—1.0	—0.1
Daisy	II + I and III	— 9.5	— 3.8	— 9.5	+0.30	+0.14	—1.23	—0.45	—1.9	—0.2	0.0	— 4.6	—0.5	—0.1
"	IV + III and V	+15.0	+ 8.5	— 6.1	+0.14	+0.16	—0.99	—0.33	—3.1	—0.5	—0.2	— 9.9	—1.7	—0.6
Regina	V + IV and VI	+ 3.1	+ 2.4	—18.9	—0.19	—0.10	—2.88	—0.94	—5.8	—0.8	—0.3	—24.4	—3.5	—1.2
Jessaline	II + I and III	—35.9	—30.1	+ 7.9	+0.20	+0 21	+1.10	+0.43	+3.9	+0.6	+0.2	+34.3	+4.5	+1.5
Rowena	II + I and III	+23.7	+26.1	+34.3	—0.14	—0.06	—5.32	+1.90	—5.7	+0.8	+0.3	+ 0.7	+0.3	+0.1
Bess	II + I and III	+ 3.6	+18.3	+28.6	+0.32	+0.19	+5.53	+2.29	+5.9	+1.2	+0.5	— 6.2	- 0.2	0.0
Total		— 1.2	+23.2	+23.0			+5.68	+2.69	+0.8	+0.7	+0.4	—25.7	—2.9	—0.8
Averages		**— 0.1**	**+ 2.3**	**+ 2.3**			**+0.57**	**+0.27**	**+0.1**	**+0.1**	**0.0**	**— 2.6**	**—0.3**	**—0.1**
Percentage differences		0	+ 2	+ 2			+ 2	+ 3	0	+1	+2	— 2	—2	—1
Salida	III + II and IV	— 6.4	— 3.8	— 5.2	—0.01	+0.04	—0.82	—0.24	—1.0	—0.1	—0.1	— 1.5	—0.3	0.0
"	V + IV and VI	+12.7	+13.8	+ 4.7	—0.07	—0.05	+0.67	+0.23	+0.2	0.0	0.0	— 5.0	—1.2	—0.3
Helena	II + I and III	— 1.7	+ 4.2	— 6.9	+0.17	+0 17	—0.80	—0.13	—1.8	—0.3	0.0	— 9.0	—1.2	—0.3
"	IV + III and V	+20.0	+13.9	— 3.7	+0.03	+0.03	—0.55	—0.18	—3.7	—0.6	—0.2	—15.7	—2.5	—1.0
Daisy	III + II and IV	— 2.0	+ 0.1	+ 0.5	+0.23	+0.12	+0.27	+0.15	+0.3	+0.1	0.0	+ 0.3	+0.2	+0.1
"	V + IV and VI	+ 9.0	+11.0	— 2.8	— 0.15	—0.13	—0.57	—0.27	—1.8	—0.3	—0.2	—18.8	—3.1	—1.2
Regina	IV + III and V	+14.2	+ 9.4	+12.8	+0.36	+0.15	+2.64	+0.90	+0.5	+0.3	+0.1	—10.5	—0.4	+0.1
Goldenrod	II + I and III	— 4.1	+ 1.8	+ 2.6	—0 09	—0.15	+0.53	+0.18	+1.0	+0.2	0.0	+ 1.9	+0.4	+0.1
Idarella	II + I and III	—35.5	—22.9	— 5.5	—0.08	—0.08	—0.92	—0.41	—4.2	—0.6	+0.2	+42.9	+6.8	+2.5
Besette	II + I and III	—10.0	0 0	+ 6.8	—0.24	—0.07	+0.86	+0.44	+3.1	+0.5	+0.2	+ 3.5	+0.4	+0.2
Total		**— 3.8**	**+27.5**	**+ 3.3**			**+1.31**	**+0 67**	**+1.0**	**+0.4**	**0.0**	**—11.9**	**—0.9**	**+0.0**
Averages		**— 0.4**	**+ 2.8**	**+ 0.3**			**+0.13**	**+0.07**	**+0.1**	**0.0**	**0.0**	**— 1.2**	**—0.1**	**0.0**
Percentage differences		**0**	**+ 2**	**0**			**0**	**+ 1**	**0**	**+1**	**0**	**— 1**	**0**	**0**
RESULT OF 360 DAYS EXPERIMENTAL FEEDING ON EACH RATION.														
	A	**7066**	**2486**	**2989**	**15.69**	**5.87**	**457.89**	**166.97**	**824.3**	**126.8**	**46.5**	**2414.2**	**367.7**	**133.4**
	B	**7064**	**2490**	**2968**	**15.63**	**5.82**	**453.51**	**164.95**	**824.5**	**126.5**	**46.1**	**2429.4**	**370.4**	**134.6**
Percentage differences	**B ± A**	**+ 2**	**+ 4**	**— 23**	**—0.06**	**—0.05**	**—4.38**	**—2.02**	**+0.2**	**—0.3**	**—0.4**	**+15.2**	**+2.7**	**+1.2**
		0	**0**	**— 1**	**— 0**	**—1**	**—1**	**—1**	**0**	**0**	**—1**	**+ 1**	**+1**	**+1**

Ratio of per cent. of fat to per cent. of solids not fat; A 1 : 1.67; B 1 : 1.69.

VII. FEEDING RECORDS OF THE INDIVIDUAL COWS IN FEEDING TESTS UPON SILAGES AND POTATOES.

(Showing pounds of each fodder and feed fed during each preliminary and each experimental period [for the silage tests] and for each calculated* experimental period [for the silage-potato tests]).

Period number.		NETT.					JERSEY LILY.				
		Hay.	Mixed grain.	Corn silage.	Bean and pea silage.	Roots.	Hay.	Mixed grain.	Corn silage.	Pean and pea silage.	Roots.
I.	Preliminary.....	80	60	389	...	71	79	60	304	...	59
	Experimental.....	144	108	789	...	..	142	108	602	...	..
II.	Preliminary.....	80	60	132	304	..	80	60	100	247	..
	Experimental.....	144	108	...	583	..	144	108	...	388	..
III.	Preliminary.....	80	60	203	...	..	80	60	176	...	..
	Experimental ...	144	108	389	...	..	144	108	339	...	..

Period number.	BESS.				GOLDEN-ROD.				REGINA.				FLOX.				JESSIE.				MARJORY.			
	Hay.	Mixed grain.†	Corn silage.	Potatoes.	Hay.	Mixed grain.	Corn silage.	Potatoes	Hay.	Mixed grain.	Corn silage.	Potatoes.	Hay.	Mixedgrain.	Corn silage.	Potatoes.	Hay.	Corn and bran.	Corn silage.	Potatoes.	Hay.	Corn and bran.	Corn silage.	Potatoes.
I.	80	60	338		80	80	438	...	80	61	331	...	80	80	326	...	100	80	322	...	100	80	231	...
II.	80	80	149	330	78	80	115	295	82	60	119	319	79	79	119	289	99	80	119	319	100	80	118	321
III.	70	80	271	12	80	80	292	12	79	60	287	10	78	84	283	12	98	84	246	12	93	84	266	12

*Errors in the conduct of the silage-potato test (noted on page 172) necessitate calculation from the actual data of feeding, and of production, as shown in the next table, in order to place the results of the feeding of the three periods upon the same basis.

†Six parts wheat bran, 4 parts corn meal, 3 parts each cottonseed and linseed meals (by weight).

VIII. RECORDS IN FEEDING TESTS ON SILAGE AND POTATOES.

(Showing for each individual cow, and for the experimental portion of each period the pounds of total dry matter in experimental fodder eaten; the pounds of milk given; per cent. of total solids and of fat; pounds of same; and pounds of milk, total solids, and fat given per 100 pounds total dry matter, and per 100 pounds dry matter in experimental fodder eaten.)

Name of cow.	Period number.	Experimental fodder.	Dry matter eaten.*	Dry matter eaten.†	Milk.	Total solids.	Fat.	Total solids.	Fat.	WEIGHT OF PRODUCTS OBTAINED PER 100 LBS. OF DRY MATTER EATEN. IN ENTIRE RATION. Milk.	Total solids.	Fat.	IN EXPERIMENTAL FODDER. Milk.	Total solids.	Fat.
			lbs.	lbs.	lbs.	%	%	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
Jersey Lily. Nett.	I	E‡	406.8	186.5	477.4	12.89	3.86	61.56	18.50	117.4	15.1	4.6	256.0	33.0	9.9
	II	S§	376.1	155.8	422.8	13.48	4.38	56.99	18.50	112.4	15.2	4.9	271.8	36.6	11.9
	III	E	304.2	83.9	371.2	13.10	4.12	48.63	15.30	122.0	16.0	5.0	442.5	58.0	18.2
Bess.	I	E	360.9	142.3	283.5	15.66	5.98	44.41	16.94	78.6	12.3	4.7	199.2	31.2	11.9
	II	S	324.0	103.7	244 7	15.94	6.43	39.00	15.73	75.5	12.0	4.9	236.0	37.6	15.2
	III	E	290.8	70.5	288.2	14.75	5.74	42.51	16.54	99.1	14.6	5.7	408.8	60.3	23.5
Golden-rod.	I	E	213.2	90.8	200.4	14.95	5.38	29.97	10.78	94.0	14.1	5.1	220.7	33.0	11.9
	II	P¶	256.5	116.1	233.6	14.75	5.34	34.44	12.48	91.1	13.4	4.9	201.2	29.7	10.8
	III	E	207.4	75.6	221.5	14.71	5.30	32.58	11.74	106.8	15.7	5.7	293.0	43.1	15.5
Regina.	I	E	258.1	117.7	184.3	13.92	4.59	25.64	8.46	71.4	9.9	3.3	156.6	21.8	7.2
	II	P	237.6	98.9	191.2	14.10	4.46	26.95	8.53	80.5	11.3	3.6	193.3	27.2	8.6
	III	E	221.7	81.3	135.6	13.95	4.60	25.89	8.54	83.7	11.7	3.9	228.3	31.8	10.5
Flox.	I	E	212.2	88.9	223.2	16.20	6.40	36.16	14.29	105.2	17.0	6.7	251.1	40.7	16.1
	II	P	229.6	105.5	198.4	16.01	6.49	31.77	12.88	86.4	13.8	5.6	188.1	30.1	12.2
	III	E	201.0	79.4	180.6	16.57	6.85	29.93	12.37	89.9	14.9	6.2	227.5	37.7	15.6
Jessie.	I	E	228.3	87.9	231.2	13.22	4.12	30.57	9.52	101.3	13.4	4.2	263.1	34.8	10.8
	II	P	248.4	109.7	217.2	12.93	3.97	28.09	8.63	87.4	11.3	3.5	198.0	25.6	7.9
	III	E	221.1	78.8	220.3	13.15	4.08	28.97	8.99	99.6	13.1	4.1	279.6	36.8	11.4
Mar-jory.	I	E	244.0	86.5	201.8	15.99	6.15	32.27	12.42	82.7	13.2	5.1	233.3	37.3	14.4
	II	P	262.2	105.5	197.7	16.20	6.25	32.02	12.34	75.4	12.2	4.7	187.4	30.3	11.7
	III	E	228.2	68.7	186.1	15.96	5.90	29.65	10.98	81.6	13.0	4.8	270.9	43.1	16.0
	I	E	219.6	62.1	129.9	15.75	6.00	20.45	7.80	59.2	9.3	3.4	209.2	32.9	12.5
	II	P	263.2	105.7	120.6	16.14	6.19	19.46	7.46	45 8	7.4	2.8	114.1	18.4	7.1
	III	E	227.2	72.1	109.9	15.60	6.10	17.14	6.70	48.4	7.5	2.9	152.4	23.8	9.3

*In entire ration. †In experimental fodder. ‡Corn silage. §Mixed silage. ¶Potatoes.

IX. DIFFERENCE TABLES. (*a*) SILAGES; (*b*) SILAGE VS. POTATOES.

(Showing differences in experimental feeding between the average of the results of two periods on one ration and those actually obtained with another ration in the intervening period.)

(*a*) SILAGES.

Names of cows.		Total dry matter eaten.	Dry matter eaten in experimental fodder.	Milk.	Total solids.	Fat.	Total solids.	Fat.	WEIGHT OF PRODUCTS OBTAINED PER 100 LBS. OF DRY MATTER. IN ENTIRE RATION. Milk.	Total solids.	Fat.	IN EXPERIMENTAL FODDER. Milk.	Total solids.	Fat.
		lbs	lbs	lbs	%	%	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs
Nett.....	Soja bean and cowpea silage (act.) + corn silage (cal.)	+20.6	+20.6	— 1.5	+0.48	+0.38	+1.89	+1.60	— 7.3	—0.4	+0.1	— 77.5	— 8.9	— 2.2
Jersey Lily		— 1.8	— 2.7	—38.2	+0.74	+0.57	—4.46	—1.01	—13.3	—1.5	—0.3	— 68.0	— 8.2	— 2.5
Totals....		+18.8	+17.9	—39.7			—2.57	+0.59	—20.6	—1.9	—0.2	—145.5	—17.1	— 4.7
Averages		+ 9.4	+ 9.0	—19.8	+0.61	+0.48	—1.29	+0.30	—10.3	—1.0	—0.1	— 72.8	— 8.6	— 2.4
Percentage differences		+ 2	+ 7	— 6	+4	+9	—2	+2	— 1	—7	—2	— 28	—23	—18

(*b*) SILAGE VS. POTATOES.

*Bess.....	Potatoes (actual) + corn silage (calculated).	+ 46.2	+ 32.9	+22.6	—0.08	0.00	+ 3.17	+ 1.22	— 9.3	— 1.5	—0.5	— 55.7	— 8.4	— 2.9
Goldenrod		— 2.3	— 0.6	+ 6.2	+0.16	—0.16	+ 1.18	+ 0.03	+ 2.9	+ 0.5	0.0	+ 0.8	+ 0.4	— 0.3
Regina....		+ 23.0	+ 21.3	— 3.5	—0.38	—0.14	— 1.28	— 0.45	— 11.2	— 2.2	—0.9	— 51.2	— 9.1	— 3.7
Flox.....		+ 23.7	+ 26.3	— 8.6	—0.26	—0.13	— 1.68	— 0.63	— 14.0	— 2.0	—0.7	— 73.4	—10.2	— 3.2
Jessie.....		+ 26.1	+ 27.9	+ 3.7	+0.24	+0.22	+ 1.06	+ 1.14	— 6.8	— 0 9	—0.3	— 64.7	— 9.9	— 3.5
Marjory....		+ 39.8	+ 38.6	+ 0.7	+0.46	+0.15	+ 0.66	+ 0.31	— 8.0	— 1.0	—0.4	— 66.7	—10.0	— 3.8
Totals		+156.5	+146.4	+21.1			+ 3.11	+ 1.62	— 46.4	— 7.1	—2.8	—310.9	- 47.2	—17.4
Averages		+ 26.1	+ 24.4	+ 3.5	0.00	+0.05	+ 0.52	+ 0.27	— 7.7	— 1.2	—0.5	— 51.8	— 7.9	— 2.9
Percentage differences		+ 10	+ 23	+ 2	0	+1	+ 2	+ 3	— 11	—11	—12	— 32	—33	—34

(*a*) Silages. Ratio of per cent. of fat to per cent. of solids not fat: Corn silage ration, 1:1.92; mixed silage ration, 1:1.78.

(*b*) Silage vs. potatoes. Ratio of per cent. of fat to per cent. of solids not fat: silage ration, 1:1.79; potato ration, 1:1.77.

*See statement made in connection with VI. Difference Tables, pages 210-211.

INDEX.

Abnormalities of Plum Blossoms 13, 89
Abstracts of Bulletins 17
" " Experiments upon Quality of Milk 152
Alternaria fasciculata 50
" " , Technical Description of 51
" Solani, Bibliography of 46
" " , Technical Description of 45
Analyses of Commercial Fertilizers compared with Guarantees 23
Announcement, Station 3
Appendix to Articles on Dairying 192
" " Report of Horticulturist 124
Apple Growing in Grand Isle County 21
" Scald 12, 55
Artificial Use of Enzyms in Germination 106
Ashes, Analyses of 30
Balance, Relative Feeding Values of two Rations of Equal 162
Bibliography of Alternaria Solani 46
" " Orange Hawkweed 73
" " Preservation of Fruits by Alcoholic Vapor 116
Blossom Charts, Plum 94
Blossoming Seasons of Plums 92
Blight of Potatoes, Fungi associated with Early 45
Board of Control, Station 2
Bordeaux Mixture, Tests of Various Forms of 12, 52
Botanist, Report of the 44
Bulletins, Abstracts of 17
Butter, Effect of Food upon the Quality of 175
Cabbage Root Maggot, A Report of the Occurrence of the 14, 116
Cannas, Italian or Orchid Flowering 14, 119
Charts Showing Dates of Plum Blossoming 94
Chemists, Report of the 28
Churning as Influenced by Changes in Feed 179
" , Exhaustiveness of 179
Classification of Plums 13, 98
Commercial Fertilizers, Analyses of 17, 18, 22, 26, 27, 28, 30
Conclusions of Economic Value in Feeding Trials 167
Contents, Table of 4
Corn Meal and Shelled Corn in Pig Feeding 11, 39
Corn Silage and Mixed Cowpea and Soja Bean Silage compared 171
Corn Silage vs. Potatoes, Feeding Trial of 173
Cowpea and Soja Bean Silage Compared with Corn Silage 171
Crops, Miscellaneous Fodder 188
" " , Necessity for 87
Dairy Apparatus, Tests of 191
Dairying 134
" Appendix to 192
Director, Report of the 8

Diseases of Potatoes and Remedies..... 12, 45
Disinfectants upon Growth of Seed Potatoes, Effect of..... 12, 53
Early Blight of Potatoes, Fungi associated with..... 45
Effect of a Change of Ration upon the Quality of Milk..... 151
Effect of Food upon Completeness of Churning..... 179
" " " Quality of Butter..... 175
" Varying period lengths upon Quality of Product..... 150
" " " " " Quantity of Product..... 149
Entomologist, Report of the..... 75
Enzyms in Germination, Artificial Use of..... 106
Equal Balance, Relative Feeding Values of two Rations of..... 162
Error in Feeding Tests, Experimental..... 165
Experiments with Fungicides on Potatoes..... 12, 52
Experimental Error in Feeding Tests..... 165
" Feeding Trials, Studies in Methods of..... 135
Feeding Changes Altering Quality of Milk..... 152
" Experiments with Pigs..... 11, 34
" Periods, The proper Length of..... 146
" Record of the Station Herd..... 187
" Trials with Silages and Potatoes..... 169
" Values of Two Rations of Equal Balance..... 162
Fertilizers, Analyses of..... 18, 26, 27, 28, 30
" " " Commercial..... 17, 22
Fertilizing Value of Rations..... 169
Financial Outcome of Feeding Trials..... 167
" Reports..... 6-7
Fodder Crops, Miscellaneous..... 188
Food upon the Quality of Butter, Effect of..... 175
Fruits Preserved by Vapor of Alcohol..... 14, 111
Fungi associated with Early Blight of Potatoes..... 45
Fungicides upon Onion Mildew, Experiments with..... 61
Germination of Seeds by use of Enzyms..... 13, 106
Grafting Machine, A new..... 14, 122
Grand Isle County, Apple Growing in..... 21
Greening Apple, Scald of the..... 12, 55
Guarantees of Fertilizers and Analyses, Comparison of..... 23
Hawkweed or "Paintbrush," The Orange..... 12, 21, 62
" , Record of the Station..... 181
Home Mixtures, Analyses of..... 28
Honeys, Analyses of..... 33
Horticulturist, Appendix to Report of..... 124
" , Report of the..... 87
Hot Water Treatment for Oat Smut..... 12, 60
Italian or Orchid-Flowering Cannas..... 14, 119
Large and Small Quantities of Skim-milk in Pig Feeding..... 11, 40
Length of Feeding Periods, The proper..... 146
Lengths upon Quality of Product, Effect of Varying Period..... 150
" " Quantity " " " " 149
Maple Products, Analyses of..... 32
Marketing Pork, Proper time for..... 41
" " Experimental Feeding Trials, Studies in..... 135
Mildew of the Onion..... 12, 61

Milk altered by Changes in Feeding, Quality of..... 152
Mill Feeds, Analyses of..... 33
Miscellaneous Fodder Crops..... 188
Muck, Analyses of..... 29
Nitrogen in Commercial Fertilizers, Availability of..... 24
Oat Smut, Effect of Hot Water Treatment upon..... 12, 60
" " , Observations upon..... 12, 59
Officers, Station..... 2
Onion Mildew..... 15, 61
Orange Hawkweed, Bibliography of..... 73
" " Eradication of..... 70
" " or "Paintbrush," The..... 12, 21, 62
" " " " , Technical Description of..... 62
Orchid Flowering or Italian Cannas..... 14, 119
Organic Nitrogen in Fertilizers, Availability of..... 24
"Paintbrush" or Orange Hawkweed..... 12, 21, 62
Peat, Analysis of..... 29
Periods in Feeding Trials, Proper Length of..... 146
Period Lengths upon Quality of Product, Effect of varying..... 150
Period Lengths upon Quantity of Product, Effect of varying..... 149
Pig Feeding..... 11, 34
Plum Blossoms, Abnormalities of..... 13, 89
" Blossoming Seasons..... 92
" Blossoming Charts..... 94
Plums, Classification of..... 13, 98
" Pollination of..... 13, 19, 87
Plum Pollination, Problems in..... 87
Pollination Affinities of Varieties and Species..... 91
" of Plums..... 13, 19, 87
" " " , Problems in..... 87
Potatoes and Corn Silage, Feeding Trial of..... 173
Potato Blight, Fungi associated with..... 45
Potato Diseases and Remedies..... 12, 45
Practical Conclusions in Feeding Trials..... 167
Preservation of Fruits by Vapor of Alcohol..... 14, 111
Public, Relation of the Station to the..... 9
Publications, Station..... 8, 15
Quality of Butter, Effect of Food upon the..... 175
" " Milk altered by Changes in Feeding..... 152
" " " Effect of a Change of Ration upon the..... 151
" " Product, Effects of Varying Period Lengths upon..... 150
Quantity of Product, Effect of Varying Period Lengths upon..... 146
Record of the Feeding of the Station Herd..... 187
" " " Station Herd, 1895-96..... 15, 181
Red Spider..... 12, 75
" " , Life history of the..... 12, 76
" " , Remedies for the..... 12, 82
Relation of the Station to the Public..... 9
Relative Feeding Values of Two Rations of Equal Balance..... 162
Report of the Botanist..... 44
" " " Chemists..... 28
" " " Director..... 8

Report of the Entomologist..... 75
" " " Horticulturist..... 87
" " " " ,Appendix to the..... 124
Report, Financial..... 67
Root Maggot of the Cabbage, A Report of the Occurence of the..... 14, 116
Salad Plants and Plant Salads..... 20
Salt as an Eradicant of Hawkweed,..... 12,70
" ,Effect upon Grass and Hawkweed of..... 72
Scald of the Apple..... 12, 55
Seed Potatoes as affected by Disinfectants, The Growth of..... 53
Selling Prices and Station Valuation, Comparison of..... 18, 24
Separators, Test of..... 15, 191
Shelled Corn and Corn Meal in Pig Feeding..... 11, 39
Silages and Potatoes, Feeding Trials with..... 169
" from Corn and from Cowpea and Soja Bean compared..... 171
Skim-milk and Whey, Feeding Values of..... 11, 42
" " " in Pig Feeding..... 11, 40
" in large and small Quantities fed to Pigs..... 12, 40
Small and large Quantities of Skim-milk in Pig Feeding..... 12, 40
Smut of Oats, Effect of Hot Water Treatment upon..... 12, 60
" " " ,Observations upon..... 12, 59
Soja Bean and Cowpea Silage compared with Corn Silage,..... 171
Spider, Red..... 12, 75
Station Announcement..... 3
" Herd, Feeding Record of the..... 15, 187
Station Herd, 1895-96, Record of the..... 15, 181
" Staff..... 2
" to the Public, Relation of the..... 9
Sterility of Plum Blossoms..... 87
Studies in Methods of Experimental Feeding Trials..... 135
Summary, Analyses of Commercial Fertilizers..... 17, 22
" Apple Growing in Grand Isle County..... 21
" Effect of Food upon the Quality of Butter..... 175
" Feeding Trials with Silages and Potatoes..... 170
" Life History of the Red Spider..... 81
" Orange Hawkweed or "Paintbrush..... 21
" Pig Feeding..... 34
" Pollination of Plums..... 19-88
" Preservation of Fruit by Alcohol Vapor..... 116
" Salad Plants and Plant Salads..... 20
" Studies in Methods of Experimental Feeding Trials..... 135
" Use of Enzyms in Germination..... 111
Table of Contents..... 4
Tests of Dairy Apparatus..... 15, 191
" " Various Forms of Bordeaux Mixture upon Potatoes..... 12, 52
Valuations and Selling Prices of Commercial Fertilizers, Comparison of..... 18, 24
Vapor of Alcohol as a Preservative of Fruits..... 14, 111
Varying Period Lengths upon Quality of Product, Effect of..... 150
" " " " Quantity " " "..... 149
Vermont, Distribution of Orange Hawkweed in..... 68
Water, Analyses of Drinking..... 31
Whey and Skim-milk in Pig Feeding..... 11, 40



